

The AMSAT[®] Journal

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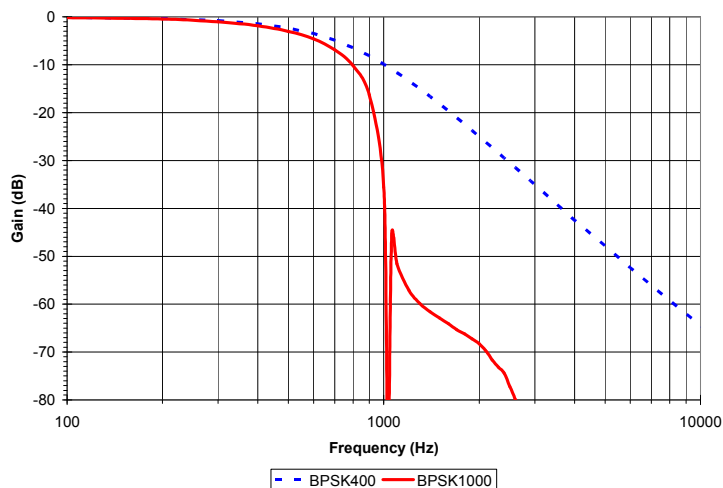


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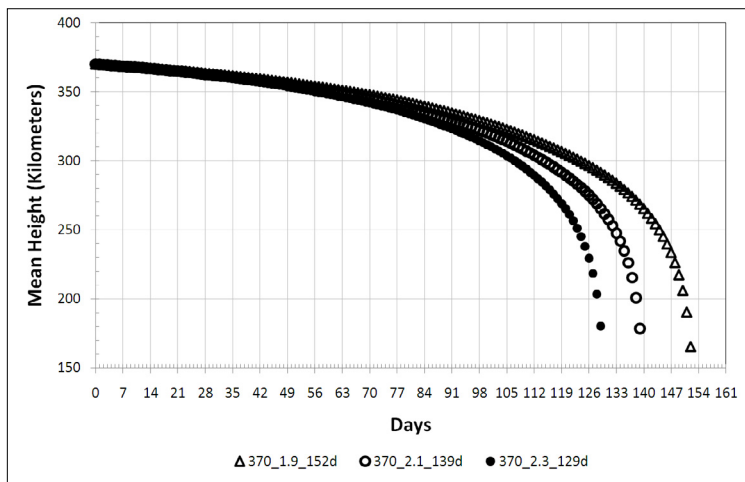
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Volume 34, Number 2

March/April 2011



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Bequest

A codicil in your will, naming The Radio Amateur Satellite Corporation as a beneficiary will help insure the continuance of the Amateur Radio Satellite program.

Call the AMSAT-NA office at 301-589-6062 for questions on any or all of these ways you can help build new and exciting satellites.

Support AMSAT-NA

AMSAT Announcements

AMSAT-NA Board of Directors Nominations

It is time to submit nominations for the upcoming open seats on the AMSAT-NA Board of Directors. A nomination requires either one Member Society or five current individual members in good standing to nominate an AMSAT member for the position. Four director's terms expire this year: Barry Baines, WD4ASW, Alan Biddle, WA4SCA, Drew Glasbrenner, KO4MA, and Tony Monteiro, AA2TX.

Beginning this year, in addition to traditional submissions of written nominations which remains unchanged and is the preferred method, nominations may be made by electronic means. These include e-mail, FAX, or electronic image of a petition. Electronic petitions should be sent to MARTHA@AMSAT.ORG or faxed to 301-608-3410. Written nominations, consisting of names, calls and individual signatures should be mailed to: AMSAT-NA, 850 Sligo Ave #600, Silver Spring, MD, 20910. No matter what means is used, petitions MUST arrive no later than June 15th at the AMSAT-NA office. If the nomination is a traditional written nomination, no other action is required. If it is other than this, i.e. electronic, a verifying traditional written petition MUST be received at the AMSAT-NA office at the above address within 7 days following the close of nominations on June 15th. **ELECTRONIC SUBMISSIONS WITHOUT THIS SECOND, WRITTEN VERIFICATION ARE NOT VALID UNDER THE EXISTING AMSAT-NA BYLAWS.** ☎

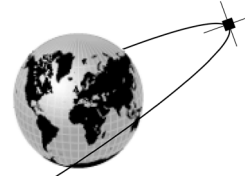
AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy satellite systems with the goal of providing wide-area and continuous coverage. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.





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Spring is a busy time of year and much has been happening within AMSAT. I'd like to take a moment to highlight some recent events as well as point out some upcoming events.

H.R. 607

Recently a bill, H.R. 607, the "Broadband for First Responders Act of 2011," was introduced by Rep. Peter King (R-NY). The bill addresses the creation of a nationwide Public Safety broadband network. The intent is good, and one that AMSAT would ordinarily support in light of Amateur Radio's long history of public service. Unfortunately, this bill contains a provision that provides for the reallocation of the 420-440 MHz block of frequencies away from its current primary and secondary users. The inclusion of most of the amateur 70 cm spectrum would actually eliminate a significant fraction of amateur resources currently dedicated to public service.

More important to satellite operators, this bill would remove the entire 70 cm spectrum allocated for the Amateur Satellite Service, constituting a more significant threat than to terrestrial operations. Terrestrial public service operations do have alternatives to using 70 cm, though they are less desirable. The 2 meter and 1 1/4 meter bands are available, though already largely committed. By contrast, almost all current and planned amateur satellites include the use of 70 cm for either uplink or downlink. If the use of 70 cm is lost, there are no reasonable alternative frequency bands for use by small satellites in low earth orbit. The next available band, 23 cm, is restricted to uplinks, has significant Doppler shift challenges and is coming under increasing pressure from global navigation services. Likewise, 13 cm is rapidly becoming unusable due to terrestrial noise sources from consumer devices on the ground. The passage and implementation of this bill will effectively end the ability to use relatively cheap, readily available amateur equipment for both traditional amateur satellite communications and university research programs that utilize the amateur satellite service.

In this rare case, we are fortunate that the primary users of these frequencies include government agencies such as the Department of Defense, Department of Homeland Security and commercial users with significant investment in the existing infrastructure. The Pave Paws

Space Surveillance Radar is an example, and one which has required the cooperation of relatively sophisticated amateurs to operate without conflict. The cost for these users to move, if possible, would require large expenditures in a time of tightening budgets. Some primary users have already spoken out against this bill, and others will do so should adoption be imminent.

However, we cannot rely on others to defeat this bill. All interested users need to lend their weight to the effort. The ARRL, AMSAT and other organizations are urging their members to contact their own senators and representatives to make them aware of the issues in this bill. More details on the impacts of this proposed legislation can be found at www.arrl.org as well as sample general amateur letters which may be edited for your use. There is an article on the main page of www.amsat.org (toward the bottom of the page) and the amateur satellite-focused sample letter may be downloaded by using the link embedded in the article.

I urge you to take the time to download the sample letter developed by AMSAT and use it as the basis for creating your own letter addressed to your representative and senators.

H.R. 607 is presently cosponsored by the Homeland Security Committee's Ranking Member, Rep. Bennie Thompson (D-MS) as well as Reps. Shelley Berkley (D-NV), Yvette Clarke (D-NY), Billy Long (R-MO), Candice S. Miller (R-MI), Laura Richardson (D-CA), Mike Rogers (R-AL), and Michael Grimm (R-NY). If you are a constituent of one of these Representatives, or Peter King, it is especially important that you contact them since your letter will have greater impact.

While most legislators can be contacted by electronic means, this is not considered to be very effective. Personal contact or written mail with signatures have more impact, but due to security concerns, there is an extensive delay by normal post. The ARRL has legislative liaison in Washington, Chwat & Co, and has graciously allowed AMSAT to submit our letters through them. They will

continued on page 21 ...



Getting Started on the Amateur Radio Satellites (Part V)

by Keith Baker, KB1SF/VA3KSF, kb1sf@amsat.org

(The bulk of this article was previously published as "How To Use Linear Amateur Satellite Transponders" in the November 2010 issue of *Monitoring Times*, Brasstown, NC 28902)

In previous columns, I've been discussing ways to find, track, listen for and then communicate through our expanding fleet of Amateur Radio satellites. In this installment, I'll be introducing you to another (non-FM) type of satellite transponder called a "linear" transponder that is carried aboard many of our current amateur satellites. I'll also discuss how our OSCAR satellites get their names on orbit.

You'll remember from previous columns that a *transponder* is the circuit in a satellite that receives an uplink signal and then retransmits what it hears via its downlink transmitter ... much like your local FM repeater does. However, unlike your local FM repeater (and most of our FM satellites which have specific input and output frequencies) most of our so-called "linear" satellite transponders (sometimes also called "analog" transponders ... the terms are often used interchangeably) receive and then retransmit a *whole band* of frequencies commonly called a *passband*.

What's more, linear amateur satellite transponders come in one of two "flavors". These transponders are usually classed as *inverting* or *non-inverting*. If the satellite has a non-inverting transponder, when an

operator's uplink signal frequency is on the high end of the uplink passband, their downlink signal will also be in the high end of the downlink passband.

Conversely, in an inverting transponder, when an operator's uplink frequency is on the high end of the uplink passband, it will become "inverted" (hence the name) and come out on the lower end of the downlink passband. Put another way, inverting transponders make mirror images of the signals they pass.

This holds true for the sideband sense as well. In a non-inverting transponder, the signals an operator sends up to the satellite (USB or LSB) will come out the same way on the downlink. However, in an inverting transponder, a USB uplink will be "inverted" and come out as LSB on the downlink. Conversely, a LSB uplink will be "inverted" and come out as USB on the downlink. The latter approach (USB signals on the downlink) is also what's most preferred by operators using our linear satellite transponders today. Fortunately, CW will be CW regardless of the transponder's variety!

Note that most linear-transponder-equipped

satellites currently in orbit (including FO-29, VO-52 and HO-68) use inverting transponders. The one exception is our old AO-7 satellite that was launched back in 1974 and which is still "sort of" operational (that is, it operates only when it is in sunlight). It uses a *non-inverting*, linear transponder.

As with the FM birds, common operating practice on amateur satellites with linear transponders is to first listen for your own signal on the downlink. You'll remember from my previous columns that working through a satellite transponder is a *full duplex* operation, much like talking on a telephone. This means that others can usually hear you as well as you are hearing yourself.

Finding your own signal in the downlink passband of a satellite with a linear transponder the first few times can be tricky. However, I've found that placing your transmit frequency somewhere in the middle of transponder's passband and then sending a few "dits" of CW while tuning your *receiver* to find your own downlink signal works best. Once you've located your own signal, you're ready to try making a contact.

However, unlike the FM birds, calling CQ on these satellites *is* acceptable and you'll usually find the convention of CW operations in the low end of the passband with phone operation in the upper part of the passband (an arrangement common to High Frequency (HF) Amateur Radio operation) generally also holds true for satellite work as well.

As I have also noted in previous columns, since a satellite is a moving target, its downlink signals will exhibit a pronounced *Doppler shift*, just like the changing pitch of a train whistle as it approaches and then passes. During a satellite QSO, the "old" (that is, prior to computer frequency control) so-called "One True Rule" of thumb for linear satellite operation is that if the uplink band is *higher* in frequency than the downlink, you should slowly shift your *transmit* frequency on the uplink as the Doppler effect changes the frequency of your downlink signal. Conversely, you should shift your *receive* frequency if the uplink band is *lower* in frequency than the downlink.

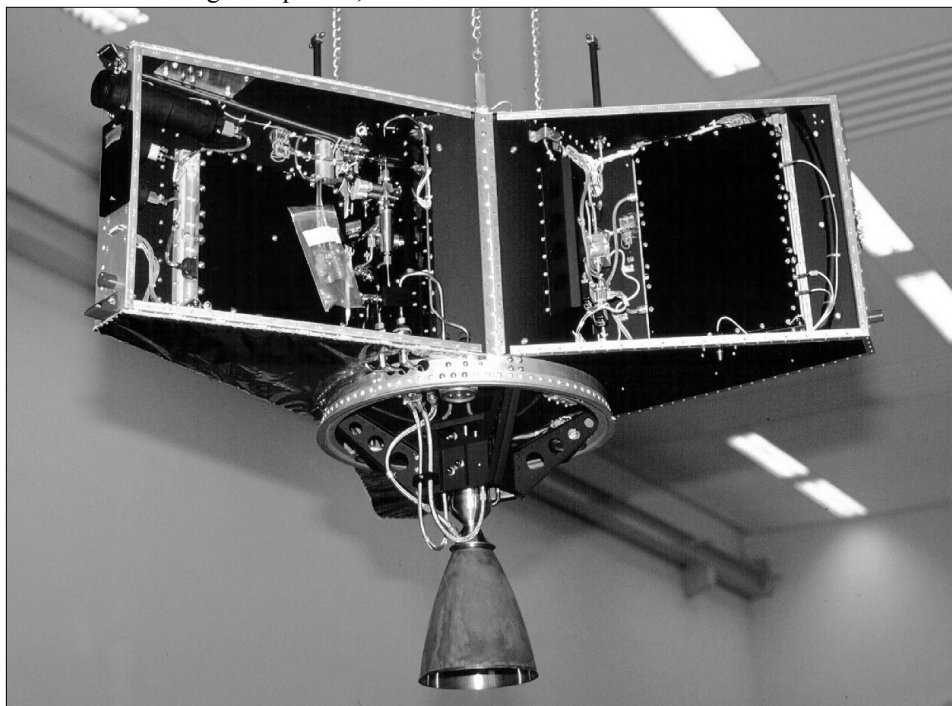


Photo1: Dubbed Phase 3-B prior to launch, the satellite that would eventually become AMSAT-OSCAR-10 on orbit hangs in the payload integration hall prior to its launch from Kourou, French Guyana. (Courtesy: AMSAT-DL)

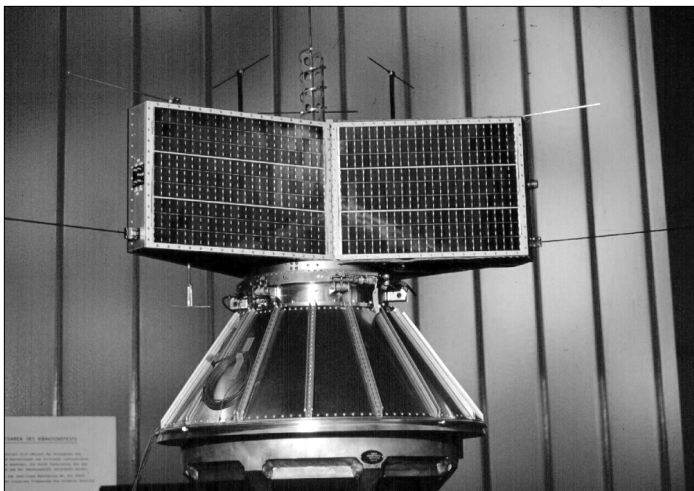


Photo 2: Phase 3-B (AO-10) sits atop its carrying structure prior to launch. Although its onboard computer was eventually hobbled by radiation damage, AO-10 provided many hams with their first taste of a truly high altitude, linear-transponder-equipped satellite. (Courtesy: AMSAT-DL)

Practically speaking, this means that you should shift your *transmit* frequency on the Mode U/V (the old Mode B) satellites, and your *receive* frequency when operating on the Mode V/U (the old Mode J) satellites. This approach will usually help prevent an inadvertent shift of your conversation into someone else's conversation on the transponder. However, unfortunately, in the "heat of the moment" with everyone frantically searching through the passband for their own downlink signals, my experience has shown that these conventions are often ignored.

Hopefully, as more and more of us employ computer-aided frequency control for



Photo 4: AMSAT's satellites are usually at the "bottom of the launch stack". Here, the faring used to protect Phase 3C (AO-13) from the rigors of launch is shown being lowered around the satellite. (Courtesy: AMSAT)

our satellite contacts, this age-old problem should eventually take care of itself. A much more detailed discussion on this (often controversial!) subject is contained on the AMSAT Web site at: http://www.amsat.org/amsat/features/one_true_rule.html

Keep The Power Down!

Because it is generated by relatively small solar panels illuminated by the Sun, satellite power is a finite (and, therefore, scarce!)

resource. That's why it is *very* important to use only enough power on your uplink transmissions to produce a readable signal on the downlink.

As I've said, when operating on the satellites, you need to get used to the idea that satellite work is *weak signal work*. It's *not* like operating on HF (or terrestrial VHF or UHF) where the use of more power is usually "better". Besides being potentially harmful to a satellite's battery life by using more uplink power than is necessary, overpowering your uplink signal beyond the point of creating a discernable signal through the satellite's linear transponder on the downlink will *not* appreciably improve the overall strength of your downlink signal.

On the contrary, such activity will do little more than "pump" the satellite's automatic gain control as it tries to compensate for the onslaught you are creating with your overpowered uplink signal. Such activity will only gobble up yet *more* of the satellite's precious available power, not to mention limiting the overall downlink power available for others using the transponder.

Unfortunately, all it takes is one overpowered uplink signal in the linear passband to drastically cut the strength of everyone else's downlink signal. As you might expect, such activity will *not* make you a popular camper on the satellites for *crocodiles* ... those who operate with "all mouth and no ears" ... are about as welcome on the birds as *lids* are elsewhere in Amateur Radio.

FM Is Particularly Unwelcome!

Also, because satellite power is such a scarce

commodity, most linear satellite transponders are built to use the most efficient operating modes possible. Normally, this equates to Single Sideband (SSB) voice and/or Morse (CW).

Therefore, it should also come as no surprise that another big "*no-no*" is running FM through linear satellite voice transponders. FM signals occupy a much larger bandwidth and take a significantly greater portion of a transponder's precious output power to handle than do CW and SSB signals. And while some people have met with moderate success operating through linear satellite transponders by "simulating CW" ... using the push-to-talk circuit on a 2 meter FM radio for example ... this approach often produces a wide (and *very* "chirpy") CW downlink signal.

Either way, your FM signals will gobble up lots of downlink power and stick out like a sore thumb. Just imagine how obnoxious you'd sound running SSB signals through your local FM repeater and I think you'll

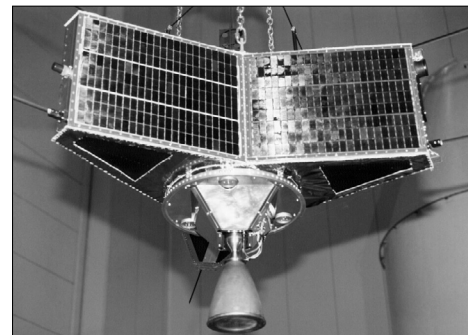


Photo 3: By far, AMSAT's most successful, high altitude linear transponder equipped satellite was Phase 3-C. Later named AMSAT OSCAR 13 (AO-13) on orbit, it provided many years of long-duration, satellite DX QSOs to users worldwide. (Courtesy: AMSAT-DL)

agree that *all* use of FM should be avoided when operating through a linear satellite transponder.

Linear vs. FM

Of course, all of this begs the obvious question as to which mode is "better". Having operated in both modes on a number of different satellites over the years, suffice it to say that neither mode is "better" than the other; they are just "different".

Clearly, our FM birds offer an easy path for newcomers to get started as they usually only require an FM handheld (and something like an Arrow or Elk handheld antenna) to use. On the other hand, because our FM birds usually operate on a single channel, they are also wonderfully popular. And because of



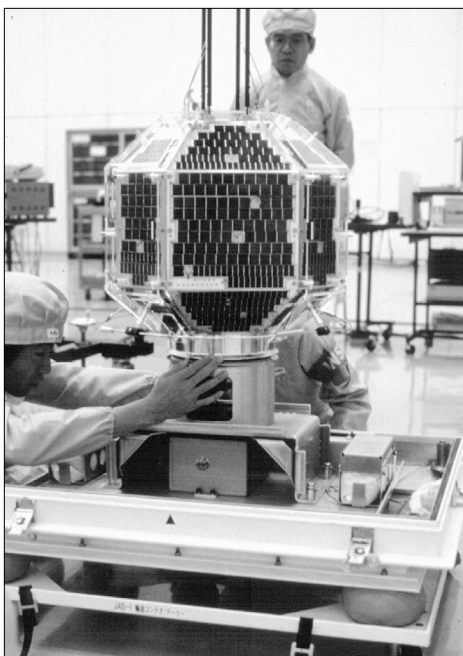


Photo 5: Technicians put the finishing touches on the launch mechanism of JAS-1B, a linear transponder-equipped satellite that later became FUJI-OSCAR 20 (FO-20) on orbit. (Courtesy JAMSAT)

the hoards of users this feature attracts, the overcrowding that results means that most of your conversations on the FM satellites will, of necessity, be of the “hello and goodbye” variety.

However, if you are even marginally equipped to operate on the linear transponder-equipped satellites (as I am these days with just a pair of “eggbeater” satellite antennas) you will often find a lot of “wide open spaces” on these satellites where you and the person you eventually hook up with can actually engage in an old fashioned “rag chew” during most (if not the entire)

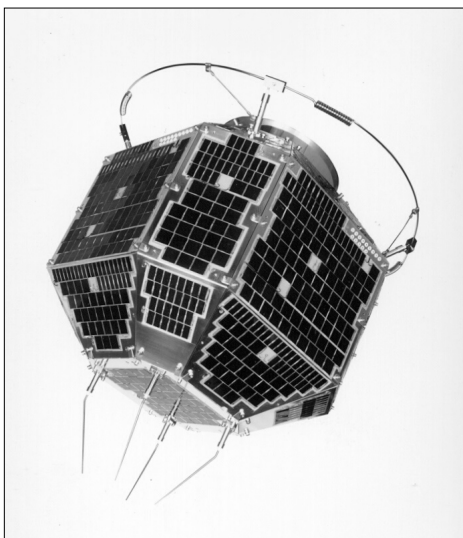


Photo 6: JAS-1B (FO-20) as it might have appeared in on orbit. (Courtesy: JAMSAT)

pass. Sadly, as of late, my experience has also shown that a lot of the bandwidth our current fleet of linear satellites now offer us on a daily basis goes begging most of the time. Clearly, because our satellites have a very definite lifetime, the old adage of “use it or lose it” very much applies.

OSCAR Who?

If you are new to the satellites, sooner or later you will probably start wondering how our amateur satellites get their names. Most newcomers know that our satellites are called “OSCARS”. But few may know how (and when) our satellites get their on-orbit numerical designations. Believe it or not, there IS a logical plan for it all!

Since 1961, some 60 plus “OSCARS” (short for Orbital (or Orbiting) Satellite Carrying Amateur Radio) have been built and launched by a number of Amateur Radio-related organizations worldwide. And just like their Hollywood counterpart of the same name, there are some very strict rules as to how our amateur satellites get to be so honored and officially become “OSCARS”.

Before launch, most of our fleet of Amateur Radio satellites are called by many other names. Indeed, for several years, AMSAT-NA has simply used a sequential alphabetical identifier for most of its satellites before launch. For example, prior to launch, our very popular AO-51 satellite was called “OSCAR-E”, “AMSAT OSCAR Echo” or just “Echo”. So, it should come as no surprise that the next satellite in this series (and the current satellite AMSAT’s experimenters are working on) is called “The Fox Project”, “AMSAT-Fox” or just “Fox”. AMSAT Fox is shaping up to be a small, so-called “1U CubeSat” that, if all goes as planned, will be an on-orbit replacement for AO-51. That’s because, after nearly 7 years in the harsh environment of space, AO-51 is getting “long in the tooth” and its batteries are now starting to show their age.

Similarly, prior to launch, our German AMSAT compatriots have traditionally referred to their string of very successful high altitude (so-called “Phase 3”) satellites

with alphanumeric designators. In that regard, their Phase 3-B satellite went on to become OSCAR 10 (AO-10), Phase 3-C became OSCAR-13 (AO-13) and Phase 3-D eventually became OSCAR-40 (AO-40) on orbit. Currently, the folks at AMSAT-DL are hard at work preparing their Phase 3-E satellite for another (as yet to be determined) high-altitude launch.

Other AMSAT organizations have used different names for their satellites prior to their launch and on-orbit activation. For example, our Japanese friends (in the JARL and JAMSAT) refer to their satellites as “Japan Amateur Satellites” (abbreviated “JAS”) followed by a number. And, true to form, their long-popular satellite, FO-29 was called “JAS-2” prior to launch.

However, once our amateur satellites are

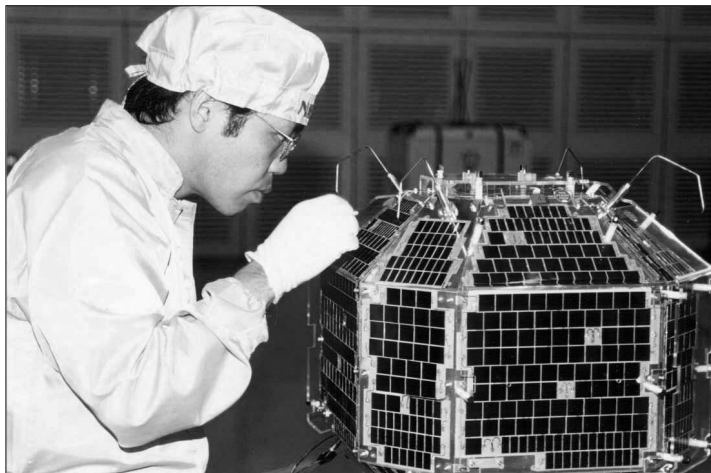


Photo 7: A technician makes a final adjustment to the JAS-2 satellite prior to launch in 1996. Later re-named FUJI-OSCAR 29 (FO-29) on orbit, the satellite is still “semi-operational” to this day. (Courtesy: JAMSAT)

successfully launched, a name change to something more universally recognized becomes necessary. Otherwise, these (largely alphabetical) designators would lead to endless confusion. But, to be called an “OSCAR” satellite on orbit, these proposed OSCAR satellites must meet a number of very specific “litmus tests”.

First, they have to be capable of transmitting and/or receiving in the Amateur Radio bands. They also have to successfully achieve orbit and be activated in space. And, lastly, the builders of the satellite have to formally request that an OSCAR number be assigned to their (now orbiting) handiwork.

Today, by mutual agreement between AMSAT and the original Project OSCAR team (the West Coast team who built and launched the very first OSCAR satellites) those formal requests all go to AMSAT

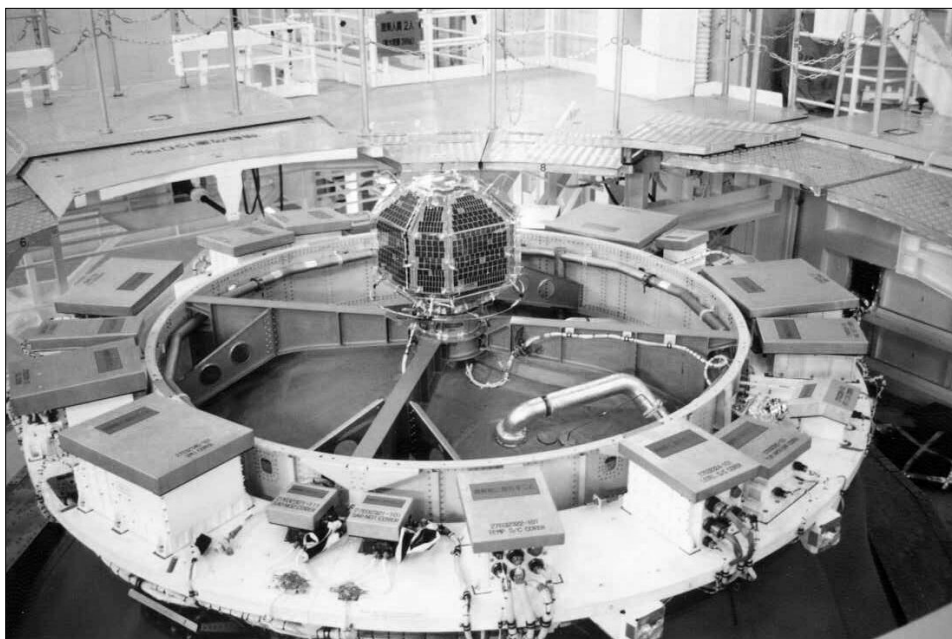


Photo 8: JAS-2 (FO-29) is dwarfed by its carrying structure. A Japanese H-II rocket launched from Japan's Tanegashima Space Center in southern Japan successfully placed the satellite into a circular, Low Earth Orbit (LEO). (Courtesy: JAMSAT)

founding member and past president, Bill Tynan, W3XO, who then passes judgment on the “amateurness” of the payload before he officially assigns an OSCAR number.

Usually, the “O” part of the on-orbit designator stands for “OSCAR”, while the number following it is sequentially assigned by Bill, depending on precisely when the satellite’s transponder was activated on orbit. However, the first letter of the OSCAR designator can stand for many things. That letter is usually suggested by the satellite’s builders or sponsors and often gives a hint

about its heritage. For example, the “F” in FO-29 stands for “Fuji” (for “FUJI-OSCAR”) while the “A” in AO-51 stands for “AMSAT” (as in “AMSAT-OSCAR 51”).

But there are exceptions to this rule and the “A” doesn’t *always* stand for AMSAT. For instance, the “A” in AO-27 stands for “AMRAD”, the suburban, Washington, DC Amateur Radio group that built the Amateur Radio satellite payload and which was later launched aboard its commercial host (called “EYESAT”) in 1993. The “S” in SO-50 stands for “SaudiSat” as a university team

in Saudi Arabia sponsored the building and launch of that satellite. However, the “S” in SO-67 also stands for “SumbandilaSat”. Sumbandila is a South African Venda word that means “lead the way”. And that satellite’s full name, when freely translated into English, means “pathfinder” as more satellites of the same type are intended to follow.

Now, if this “alphabet soup” all sounds a bit confusing, that’s probably because it is! Just remember that the letter “O” in a satellite’s official, on-orbit name followed by a dash and then one or two numbers *usually* indicates that the satellite is one of our fleet of Amateur Radio (OSCAR) satellites.

Wrap Up

That’s all for this installment of my “getting started” series. In future columns, I’ll be discussing some more interesting aspects of this unique part of the Amateur Radio hobby as well as to bring you up to date on the history and current status of some of our on-orbit satellites, including a discussion about the Amateur Radio equipment now being carried aboard the International Space Station. See you then. 🌐

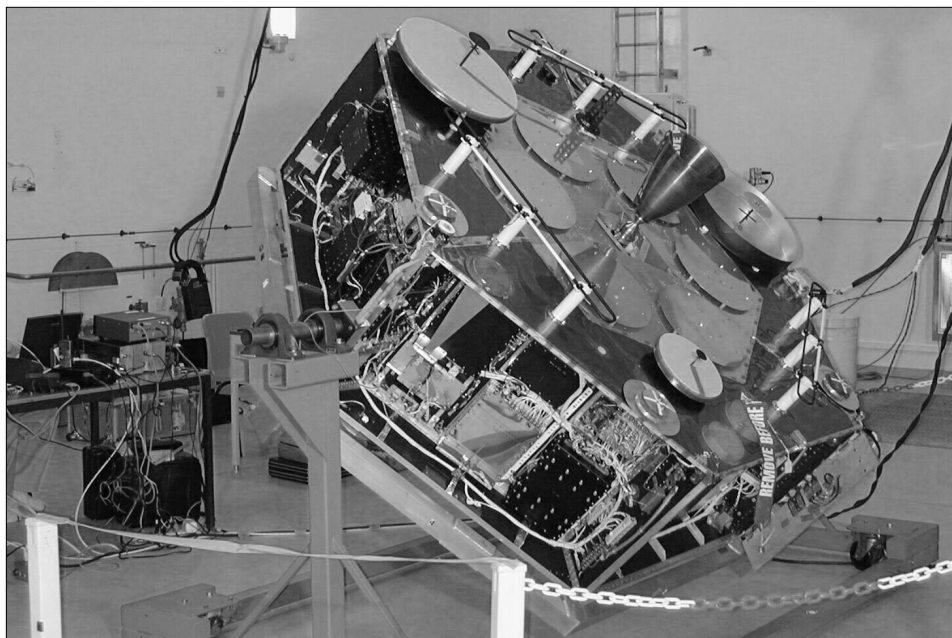


Photo 9: AMSAT's Phase 3-D satellite (later renamed AMSAT-OSCAR 40 on orbit) awaits final integration at ArianeSpace's Guiana Space Center in Kourou, French Guiana in November, 2000. (Courtesy: AMSAT)

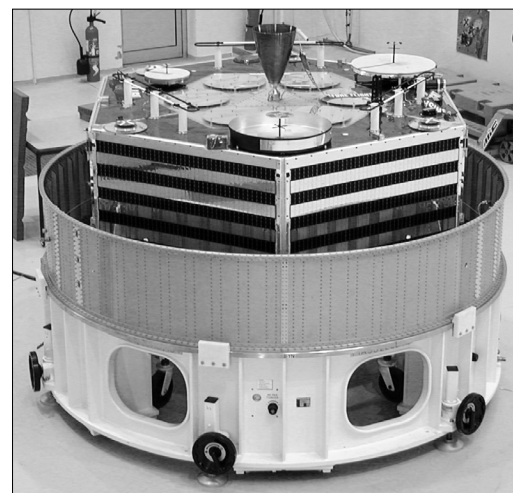


Photo 10: Phase 3-D (AO-40) is shown here neatly tucked inside its Specific Bearing Structure (SBS) prior to launch in 2000. AMSAT's experimenters designed, built, tested and then later freely provided that SBS design to the European Space Agency in exchange for a reduced “ticket to ride” for Phase 3-D. (Courtesy: AMSAT)





Introduction

The ARISSat-1 satellite includes a unique radio experiment that AMSAT calls a *software-defined transponder* or *SDX*. [1] The SDX provides radio modulation and demodulation functions in software providing a capability and flexibility far beyond that of a typical hardware-based transponder. While software radio technology is rapidly becoming common in terrestrial radio systems, ARISSat-1 will be the first amateur satellite to rely on it for the primary mission. This mission will provide a crucial test of the technology as AMSAT plans to fly a similar capability on our upcoming *Fox CubeSat*.

RF Band Plan

The downlink band from ARISSat-1 ranges from 145.918 MHz to 145.958 MHz. The downlinks include a CW beacon, digital beacon, FM audio downlink and a linear, inverting transponder. All of these signals operate simultaneously and their frequencies are shown in the center column of Table 1. A full color frequency guide is also available on the AMSAT Web site. [2]

There are two CW beacon frequencies that are available, although we plan to use CW2 on 145.919 MHz exclusively. The CW beacon sends Morse code at 15 words per minute and includes the satellite call sign, several key telemetry values and the call signs of significant ARISS and ARISSat-1 contributors. There are over 200 contributor call signs so collecting them all should present a fun challenge for Morse code enthusiasts.

The digital beacon at 145.920 MHz uses Binary Phase-Shift Keying (BPSK.) This beacon carries the satellite telemetry and the Kursk experiment data. There are two

different digital beacon schemes included in the SDX software.

The main digital scheme is a new mode called BPSK1000 that was developed specifically for ARISSat-1. This mode has a raw data rate of 1000 bits per second and includes substantial forward error correction (FEC) coding resulting in a useful throughput of around 500 bits per second. BPSK1000 can provide error-free reception under very deep fading and weak signal conditions. In lab testing, it was possible to actually turn off the ground receiver, wait a moment, and then turn it back on without missing any telemetry frames. As a result, it should be possible to receive the digital beacon using only a simple omnidirectional antenna on the ground. When this mode is operating, the CW2 beacon frequency will be activated.

The software programmability of the SDX makes it easy to include an alternate digital scheme. That scheme is the well-proven BPSK400 mode, used on all of the Phase 3 satellites including AO-40. We do not expect to activate BPSK400 in orbit, but it was useful during testing and is available as a backup. If BPSK400 is activated, the CW1 beacon frequency will be used to indicate this.

The FM audio downlink is on 145.950 MHz. Voice announcements sent on this downlink include the call sign, several key telemetry values and 24 greeting messages from children in 15 different languages. A special

message from Yuri Gagarin is also included to commemorate the 50th anniversary of his famous flight.

ARISSat-1 has four slow-scan television (SSTV) cameras. The captured SSTV images will be sent as audio in Robot 36 format and are interspersed with the voice announcements on the FM audio downlink.

Finally, ARISSat-1 has a linear, inverting transponder that is 16 kHz wide. The downlink range is from 145.922 MHz to 145.938 MHz and the corresponding up-link range is from 435.758 MHz to 435.742 MHz. This transponder will support several SSB and CW QSOs simultaneously. Since it is inverting, ground stations should transmit lower side band on the uplink and receive upper side band on the downlink.

SDX Hardware

The inputs and outputs of the SDX are at an intermediate frequency (IF) of 10.7 MHz. The output of the SDX drives a 2-meter transmitter that is basically an up-converter from 10.7 MHz to 145 MHz followed by a linear power amplifier with a maximum power output of 500 mW. A 435 MHz receiver that is essentially a low-noise, down-converter feeds the input of the SDX. Its local oscillator is above 435 MHz so the IF band to the SDX is inverted.

The SDX hardware consists of a digital demodulator, a digital modulator and a digital processor. Those old hands who remember



Veronica Monteiro shows off an engineering model of the SDX card.

Signal	Frequency (MHz)	IF Offset (kHz)
CW1 Beacon	145.939	+1
CW2 Beacon	145.919	-19
Digital Beacon	145.920	-18
FM Audio	145.950	+12
Transponder Output	145.922 -145.938	0 to -16
Transponder Input	435.758 - 435.742	0 to -16

Table 1: ARISSat-1 Frequencies

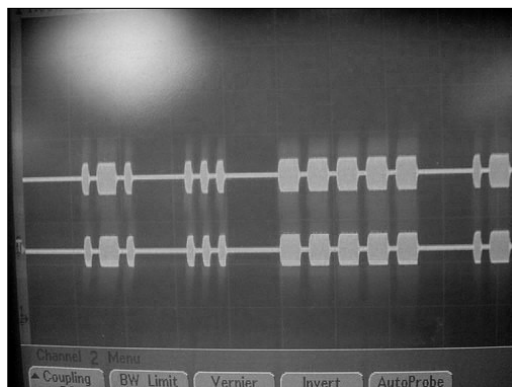


Figure 1: CW Beacon.

phasing SSB receivers and exciters may notice a familiarity in the demodulator and modulator descriptions.

The digital demodulator takes an analog input at 10.7 MHz. The input is split into two equal and in-phase signals and fed to a pair of double balanced mixers (DBMs.) A 10.7 MHz local oscillator provides outputs at 0 and 90 degree phases and each phase is fed to one of the DBMs. Each DBM output drives a 20 kHz anti-aliasing filter followed by a 16-bit, analog-to-digital (A/D) converter running at 48 k samples per second. The A/D output from the DBM driven by the 0-degree oscillator signal provides the in-phase or I samples. The A/D output from the DBM driven by the 90-degree oscillator signal provides the quadrature-phase or Q samples. The I and Q samples together provide all of the information needed to capture a 40 kHz bandwidth centered on 10.7 MHz.

The digital modulator does the opposite of the digital demodulator. The input I and Q samples each drive a 16-bit, digital to analog (D/A) converter running at 48 k samples per second. Each D/A converter has a 20 kHz low-pass filter on its output. The filtered D/A outputs each drive a double balanced mixer. As before, a 10.7 MHz local oscillator provides signals at 0 and 90 degrees and each phase is fed to one of the DBMs. The DBM outputs are then combined to create the IF output signal. The digital modulator provides a 40 kHz output bandwidth centered on 10.7 MHz.

The digital processor runs the digital signal processing (DSP) software and consists of a Microchip PIC32 embedded controller with 512K of FLASH program memory and 32K of RAM. The CPU runs at 80 MHz. The PIC32 includes direct memory access (DMA) channels that are used to service the A/D and D/A converters reducing the load on the CPU. The PIC32 also has a Serial

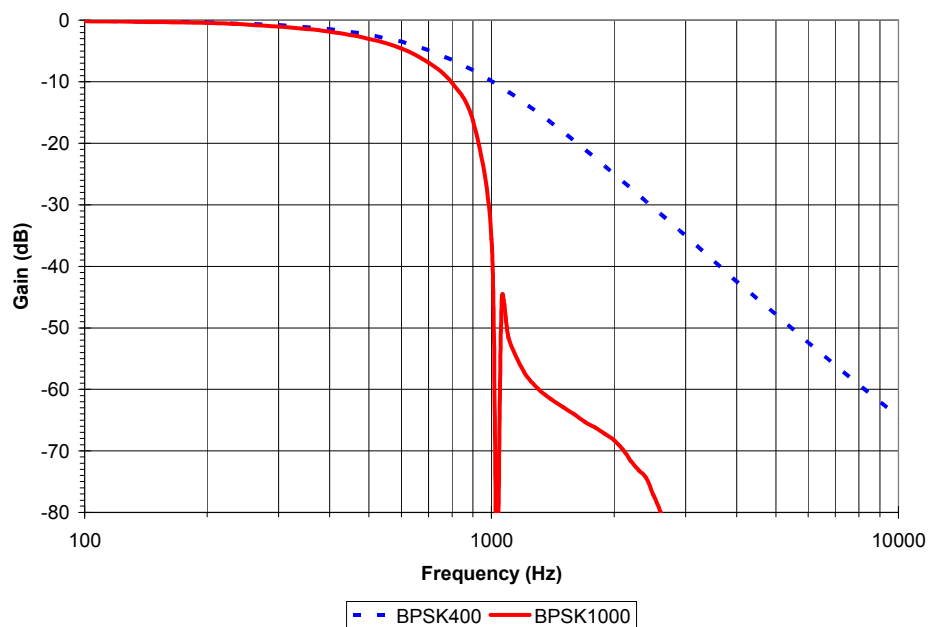


Figure 2: BPSK Filters.

Peripheral Interface (SPI) that is used to communicate with the IHU card. The IHU card has another PIC32 and is the source of the Morse code, digital beacon and FM audio data to be modulated and transmitted on the downlinks.

SDX Software

Software on an embedded controller like the PIC32 is a markedly different environment than software intended for a PC. With an 80 MHz CPU clock speed, it imperative that the limited CPU cycles be used very judiciously. Typical PC-based, software defined radios use an algorithm known as the fast Fourier transform (FFT) to convert

the A/D samples to a frequency spectrum much like a spectrum analyzer. This makes things like “brick wall” filters very easy to implement. But this approach is not practical on the SDX because the FFT itself is very CPU intensive. Instead, all signal processing on the SDX is done directly in the time domain with the actual samples. While more difficult from a software design standpoint, this approach makes much better use of the available CPU.

The PIC32 does not include a floating-point processor so to save CPU cycles, integer math is used exclusively. The “Q” number format [3] was adopted to facilitate

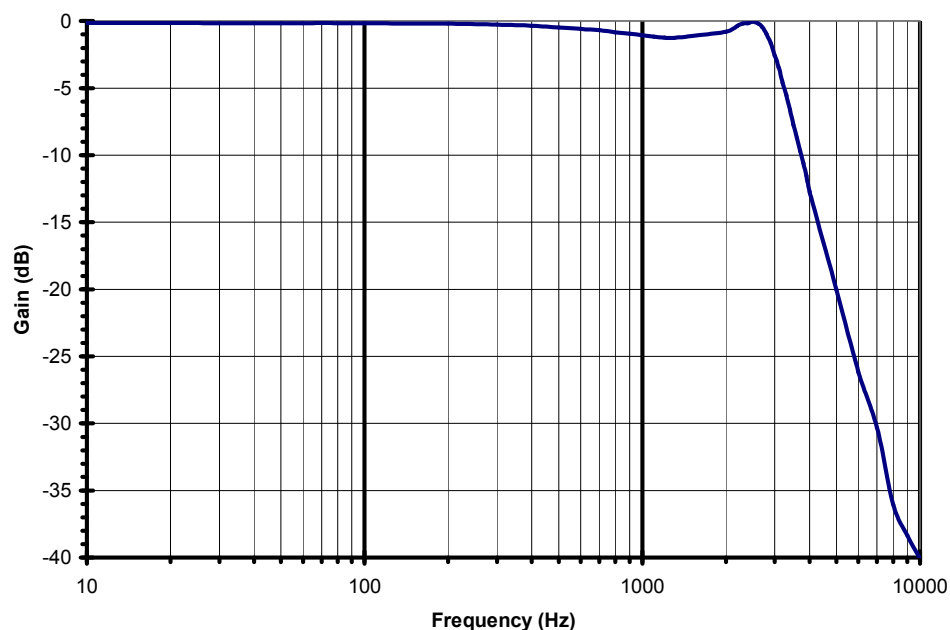


Figure 3: FM Audio Response.

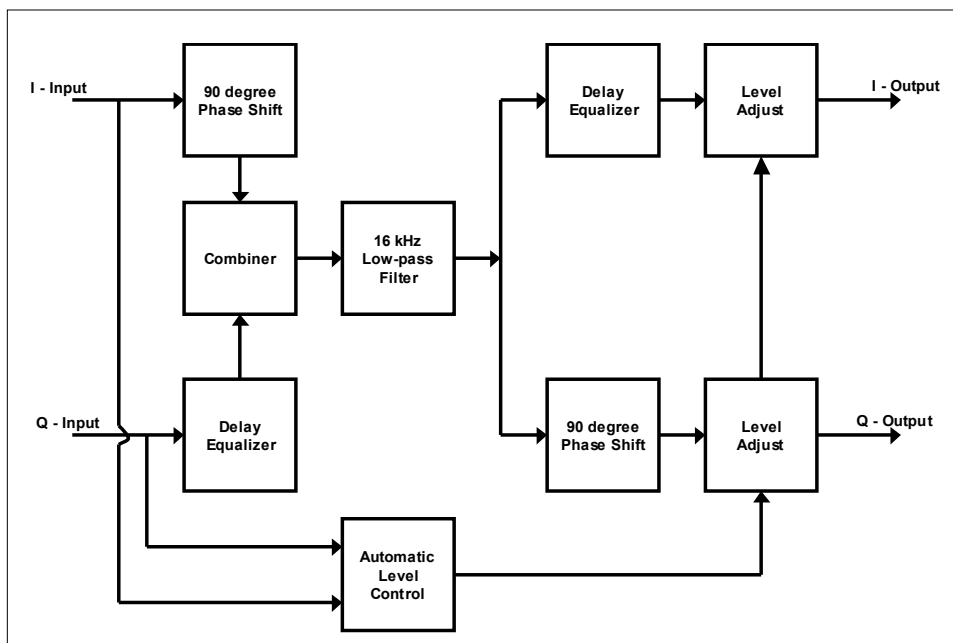


Figure 4. Linear Transponder

fixed-point math operations using the PIC32 integer math hardware. This number format has been widely promoted by Texas Instruments for their DSP products that do not have floating point math processors. Most of the internal math for the SDX is done using Q15, a format that provides 15 fraction bits and allows numbers within the range -1 to $+1$ to be represented. This normalized range is converted to real-world numbers when needed.

No operating system is used on the SDX to avoid any extra overhead and context switching CPU cycles. Instead, the software is organized as a simple repeating main loop. The execution of this main loop is synchronized with the A/D and D/A conversions and runs every 1 millisecond. The A/D and D/A conversions are handled in blocks of 48 I/Q samples using a double-buffer scheme. The signal processing software operates on one set of these buffers while the DMA channels are handling the transfers of the alternate set with the A/D and D/A converters. After the DMA transfers are complete, the buffers are swapped and the process repeated. The SPI communications channel to the IHU is also double-buffered and transferred via DMA which helps free up more CPU cycles to be used for signal processing.

The signals at the SDX inputs and outputs are offset from the 10.7 MHz center frequency as shown in the third column of Table 1. For example, the CW2 beacon is -19 kHz from the 10.7 MHz center frequency, which puts

it at 10.681 MHz. These offset frequencies are notable because the SDX manipulates them in software. The DSP software, to be described next, calculates 1 millisecond worth of I/Q samples at a time for each of the downlinks and adds them together in the buffers that are then transferred to the D/A converters.

CW Beacon

The simplest signal to generate is the CW beacon. The Morse code to be transmitted comes from the IHU as a 1-bit binary signal with 0 representing "off" and 1 being "on." The Morse code is applied to the input of a pulse-shaping filter. This provides an exponentially shaped, 5 millisecond rise and fall time for the Morse code signal as recommended by the ARRL. This shape prevents key clicks while retaining a nice punchy sound for copying by ear.

A software oscillator provides 0 and 90 degree signals at one of the two possible beacon frequencies. The oscillator frequency is the "IF Offset" shown in Table 1 and can be set to either $+1$ kHz (CW1) or -19 kHz (CW2) by a command from the IHU. Note that a negative frequency means that the oscillator phase is inverted.

The pulse shaper and oscillator outputs drive a pair of software double balanced mixers. In software, this means they are multiplied together and adjusted to compensate for the integer math. The mixer outputs are then multiplied by a real world conversion factor to drive the I and Q inputs of the digital modulator hardware. Due to the phasing of

these samples, the output signal will appear only at the desired IF offset frequency and not the mirror image signal which will be cancelled out (i.e. at $+19$ kHz for CW2.) The CW beacon signal drives the 2 meter transmitter to a 25 mW output level. A scope trace showing the CW beacon in operation is shown in Figure 1.

Digital Beacon

The digital beacon uses binary, phase-shift keying (BPSK.) The data to be transmitted comes from the IHU as a 1-bit binary signal at either 400 or 1000 bits per second. The binary input is applied to a pulse-shaping filter. Two filter types are available. For BPSK400, the hardware filter from AO-40 was directly implemented in software. This is a 3-pole, Bessel filter and provides the frequency response shown by the dashed line of Figure 2. BPSK1000 uses a much more sophisticated 455-tap FIR filter and has a much sharper frequency response as shown by the solid line in Figure 2. The sharper response means that the BPSK1000 signal occupies less bandwidth than BPSK400 even though it provides a higher bit rate. This same filter is reused in the ARISSat-1 ground station telemetry decoding software and its sharp frequency response provides a high discrimination against noise, aiding in signal detection.

A software oscillator provides 0 and 90 degree signals at the digital beacon IF offset frequency of -18 kHz. The pulse-shaping filter and quadrature oscillator outputs are fed to a pair of software double balanced mixers just as is done for the CW beacon. The mixer outputs are multiplied by a conversion factor so that the digital beacon will appear as a 100 mW signal at the transmitter output.

FM Audio

The FM audio signal comes from the IHU as a block of 48, 8-bit samples representing 1 millisecond worth of audio to be modulated. These samples include voice announcements created from WAV files stored on the IHU as well as SSTV images from a Robot 36 encoder. The audio samples are applied to a 3 kHz low-pass filter to prevent over-modulation. This is implemented as a 3rd order Chebyshev filter and it has a nearly flat frequency response over the pass-band with a sharp cutoff at 3 kHz as can be seen in Figure 3.

A software oscillator provides 0 and 90 degree carrier signals at the IF offset frequency of $+12$ kHz. The filtered audio

and carrier oscillator samples are applied to a pair of software phase modulators. The phase modulators calculate the instantaneous modulation angle and are set to produce 5 kHz deviation. The phase modulator outputs are the software oscillator signals with their phases adjusted by the calculated modulation angle. The phase modulator outputs are multiplied by a conversion factor so that the FM downlink will appear as a 250 mW signal at the transmitter output. Since FM is a non-linear process, this signal includes many sidebands and can occupy up to 16 kHz of bandwidth depending on the exact characteristics of the modulating signal.

Linear Transponder

A block diagram of the signal processing for the linear transponder is shown in Figure 4. The I samples from the A/D converter are fed to a 32-tap Hilbert Transformer which shifts the phase of those samples by 90 degrees. Since there is a delay through the Hilbert Transformer, the Q samples are fed to a delay equalizer so that the I and Q samples will be back in sync. The samples are then combined which is equivalent to just adding them with an adjustment for the fixed-point math. The combination of these operations forms a wide-bandwidth, lower sideband receiver that provides over 30 dB of rejection of the frequencies above 10.7 MHz while passing all of the frequencies below 10.7 MHz.

The lower sideband signal range extends from 0 to -20 kHz from the 10.7 MHz center frequency. With the digital beacon signal centered at -18 kHz and the CW2 beacon at -19 kHz, the potential exists for transponder users to cause interference to the beacons. Since this is highly undesirable, a 16 kHz low-pass filter is used to limit the passband to the range from 0 to -16 kHz. This is implemented as an 18-tap, sinc filter and its frequency response provides a very sharp cutoff protecting the beacons from interference.

The output of the low-pass filter is applied to a 64-tap Hilbert Transformer which provides a 90-degree phase shift, and a delay equalizer to keep the outputs in sync. In combination with the I/Q modulator, this forms a wide-bandwidth, lower sideband transmitter. The upper sideband rejection exceeds 40 dB and prevents any interference to the FM audio downlink.

The linear transponder has an automatic level control (ALC) function. The ALC monitors the input samples and adjusts the output sample levels to keep the RF

transmitter power in a reasonable range. It has a fast-attack, long-delay characteristic to work best with SSB and CW signals. The ALC prevents overdriving the RF transmitter and will limit the total power of the pass band signals to no more than 125 mW.

Current Status

ARISSat-1 was completed in October of 2010 and launched on Progress 41 up to the ISS in late January of this year. It is currently awaiting deployment via an EVA scheduled for July. In the meantime, there is an operating event planned for April 12th to commemorate the 50th anniversary of Yuri Gagarin's famous flight. A coax jumper will be run from ARISSat-1 to a 2-meter antenna outside the ISS and the satellite will be switched on. The linear transponder will not be operational since there will be no 70 cm antenna connected. All of the other downlinks from the SDX will be active.

ARISSat-1 will be operating in low power mode during this event which saves battery power. In this mode, the transmitter will be on for about 40 seconds at a time. This is long enough to send voice announcements or a pre-loaded SSTV image on the FM audio downlink, a BPSK1000 telemetry frame and several Morse code messages. The transmitter will then shut down for about 2.5 minutes and the cycle will repeat. This operating event will provide an opportunity to hear the actual satellite transmissions.

Acknowledgements

Development of the SDX required a significant team effort. Besides the DSP code, many software modules are needed to have a working unit including diagnostics, configuration and initialization code, DMA controller software, device drivers and test tools. Bill Reed, NX5R, Jim Johns, KA0IQT, Jerry Zdenek, N9YTK, Joe Julicher, N9WXU and Joe Fitzgerald, KM1P, were the major contributors on the SDX software team. Phil Karn, KA9Q, developed the new BPSK1000 mode specifically for ARISSat-1. Steve Bible, N7HPR, designed the SDX hardware and built all of the circuit boards. Lou McFadin, W5DID, Stan Wood, WA4NFY, and George Presley, K4RSV, extensively tested the RF links including running the linear transponder with live QSOs. And finally, Microchip Corporation deserves a special mention for providing components and development tools and for allowing the ARISSat-1 team to use their facilities for satellite development work.

Footnotes

- [1] Bob McGwier, N4HY, is credited with coining the terms software defined transponder and SDX.
- [2] ARISSat-1 Frequency Guide is available at www.amsat.org
- [3] For more information on Q number formats, see [http://en.wikipedia.org/wiki/Q_\(number_format\)](http://en.wikipedia.org/wiki/Q_(number_format)) ⓘ

The AMSAT Store (see www.amsat.org) is back online! Here is a new AMSAT product. A handsome and functional AMSAT 10' locking carpenter's tape with both inch and metric scales.

Minimum donation: \$5



Another Successful Greater Houston Hamfest

Allen F. Mattis, N5AFV, n5afv@amsat.org

AMSAT was well represented this year at the Greater Houston Hamfest (GHH) held March 5, 2011 at the Fort Bend County Fairgrounds in Rosenberg, Texas, southwest of Houston. The GHH is the second largest, and the fastest growing, hamfest in Texas. This year the GHH again hosted the American Radio Relay League (ARRL) South Texas Section Convention. Harold Kramer, WJ1B, chief operating officer of the ARRL, was the featured speaker.

The GHH had over 18,000 square feet of indoor exhibit space, tables for vendors and individuals, Amateur Radio related presentations, exhibits, VE test sessions, and a free tailgate area with early buyer access before the main hall opened. QSL-card checking for the ARRL VUCC award was provided by AMSAT Director of Contests and Awards, Bruce Paige, KK5DO.

The AMSAT booth was manned by Andy MacAllister, W5ACM, and Bruce, KK5DO,

along with assistance from Allen Mattis, N5AFV, Mike Scarcella, WA5TWT, Charlie Keng, K5ENG, A.C. Spraggins, W5EZM, and Tony Summerville, N5RPQ. A non-ham, electrical engineer from India stopped by the AMSAT booth and was very surprised to learn that Amateur Radio operators use satellites. He was even more surprised to learn that India has a very active AMSAT group and has even built and launched

continued next page ...



Photo 1: Andy, W5ACM, and Bruce, KK5DO, put final touches on the AMSAT booth. (Photograph provided by N5AFV)



Photo 2: George, WA5KBH, contended with very strong winds during the satellite demonstration. (Photograph provided by Travis Burgess, K5HTB)



Figure 3: Allen, N5AFV, operating a receiving station at the satellite demonstration while David Bankhead, KC5LSP, looks on. (Photograph provided by Travis Burgess, K5HTB)



Figure 4: Will, N5ESA, operating a receiving station at the satellite demonstration. (Photograph provided by W5ACM)

VUSAT OSCAR-52. Hopefully his interest was piqued enough that he will become a licensed radio amateur.

A satellite demonstration was conducted during an almost overhead pass of Saudi OSCAR-50. A cold front accompanied by rain showers moved through the area just prior to the satellite pass. Fortunately the rain had stopped in time for the pass, but there were sustained NNW winds of 28 mph with gusts to 45 mph during the satellite demonstration. It was difficult to hold an Arrow antenna steady in the strong wind gusts, but George Carr, WA5KBH, successfully made a dozen contacts with his Icom W32A and Arrow antenna. Approximately 18 people braved the cold and winds for the satellite demonstration. Receive-only stations were operated by Will Thomas, N5ESA, Andy, W5ACM, Allen, N5AFV, and Jack Wilson.

Following the satellite demonstration, Allen, N5AFV, presented a talk entitled "ARISSat-1 – AMSAT's Newest Satellite" that was attended by 25 people. Harold Kramer, WJ1B, from the ARRL was speaking at the same time in another room. This cut into attendance at the AMSAT talk, but the audience was very interested in hearing about the upcoming deployment of ARISSat-1 and the April 12, 2011, Yuri's Night activities. After the presentation there was an increase in both traffic and sales at the AMSAT booth.

The Brazos Valley Amateur Radio Club (BVARC), organizer of the hamfest, fully supported the AMSAT activities this year with a great raffle prize - a Kenwood TH-F6A HT, Arrow antenna and duplexer. The lucky winner was Tim Koehl, KO3HL, of Houston. Many favorable comments from attendees regarding the AMSAT activities were received by the event managers. 🌐

AMSAT is the North American distributor of SatPC32, a tracking program designed for ham satellite applications. For Windows 95, 98, NT, ME, 2000, XP, Vista, Windows 7.

Version 12.8a is compatible with Windows 7 and features enhanced support for tuning multiple radios.

Version 12.8a features:

- Select 2D/3D map with a single mouse click
- Select Political/Physical map with a single mouse click
- AOS voice announcement
- Countdown program displays next AOS of your favorite satellites
- Automatic Internet download of Keplerian elements.
- Graphical tracking on a world map with two selectable Zoom factors.
- One-click satellite switching using 12 "letter" buttons.
- Automatic rotor control support for: LVBTracker, Kansas City Tracker/Tuner, FODtrack, Uni_Trac, SatEL, Labjack U12/U3/Piggyback, W0LMD Mini/Junior/Senior Trackers, Yaesu GS-232, ARS from EA4TX, EGIS rotors, IF-100, RIF-PC, AMSAT-DL interface, WinRotor32, HalloRotor, and WiSP DDE clients.
- Doppler tuning with on-screen frequency displays. Radio models supported:
Yaesu FT-847, FT-736R, FT-817, FT-857, FT-897
ICOM IC-820H, IC-821H, IC-910H and other ICOM radios
Kenwood TS-790 and TS-2000
DDE client programs
- "Transparent" VFO-knob tuning in addition to keyboard and mouse tuning.
- "Virtual" VFO tracking for half-duplex transceivers FT-817, FT-857, FT-897, IC-706 and IC-7000.
- Includes a special version for ISS split-frequency operation.
- Controls subaudible tone on FT-847, FT-736R, FT-817/857/897, TS790A and IC-910H.
- Includes a non-graphical version and programs that output lists to the screen, printer, or a file.
- Interfaces with WiSP, with user-defined satellite switching priority.
- Includes a separate program for tracking the Sun and Moon.

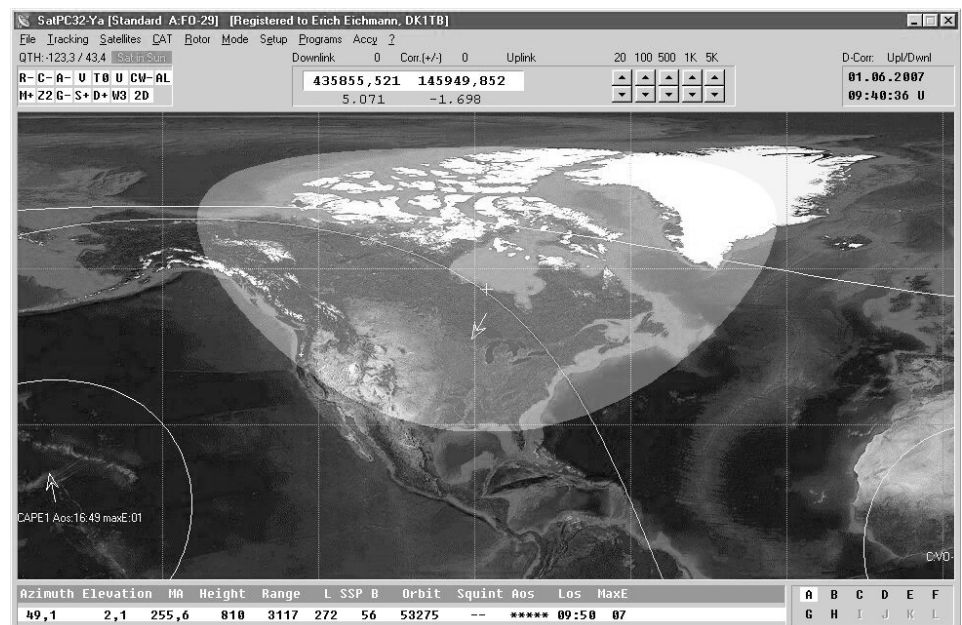
Minimum Donation is \$45 for AMSAT members, \$50 for non-members, on CD-ROM.

A demo version may be downloaded from <http://www.dk1tb.de/indexeng.htm>

A registration password for the demo version may be obtained for a minimum donation of \$40 for members and \$45 for non-members.

Order by calling 1-888-322-6728.

The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.



AMSAT Board of Directors Meeting Minutes

October 7 & 8, 2010

Chicago/Elk Grove, IL

The meeting was called to order by AMSAT President Barry Baines, WD4ASW, at 0810 CDT on Thursday, October 7, 2010.

Members of the Board of Directors present:

Barry Baines, WD4ASW, President
Tom Clark, K3IO
Lou McFadin, W5DID
Drew Glasbrenner, KO4MA, Vice-President, Operations
Gould Smith, WA4SXM, Vice-President, User Services
Alan Biddle, WA4SCA, Secretary
Tony Monteiro, AA2TX, Vice-President, Engineering

Other officers present:

Keith Baker, KB1SF/VA3KSF, Treasurer
Martha Saragovitz, Manager

Among the AMSAT members participating and/or observing during the meeting:

Bob Davis, KF4KSS
Bob McGwier, N4HY
Bryan Klofas, KF6ZEO
Craig Bledsoe, KL4E
Dale Hershberger, KL7XJ
Dan Schultz, N8FGV
Dave Taylor, W8AAS
Dee Interdonato, NB2F
Dick Daniels, W4PUJ
Douglas Quagliana, KA2UPW
Jennifer Rojowski, N8GZL
JoAnne Maenpaa, K9JKM
John Paypay, K8YSE
John Shew, N4QQ
Keith Pugh, W5IU
Larry Brown, W7LB
Mark Hammond, N8MH
Nick Pugh, K5QXJ
Patrick Stoddard, WD9EWK/VA7EWK
Phil Kam, KA9Q
Sharon D. Davis, KJ4YOV
William Reed, NX5R

Barry opened by presenting the slate of Board officers for approval:

President, Barry Baines, WD4ASW
Vice-President, Operations, Drew Glasbrenner, KO4MA
Vice-President, User Services, Gould Smith, WA4SXM
Vice-President, Engineering, Tony Monteiro, AA2TX

Secretary, Alan Biddle, WA4SCA
Treasurer, Keith Baker, KB1SF/VA3KSF
Manager, Martha Saragovitz

It was moved by Tom and seconded by Lou that the slate be adopted. The vote for approval was unanimous.

The following Officer positions are currently open:

Executive Vice-President
Vice-President, Human Spaceflight
Vice-President, Marketing

Barry reviewed the schedule of events for the Board meeting, including scheduling changes and outside speakers who wished to address the Board on various issues.

Executive and Other Team Reports **President's report by Barry Baines, WD4ASW**

Barry previewed his general report to the membership. The major limiting issue for AMSAT-NA continues to be the restrictions imposed by ITAR. Despite several attempts to move AMSAT to a less restrictive status, we are still severely limited in our ability to cooperate with our foreign colleagues. Since further expensive legal efforts are not expected to provide any relief, AMSAT will proceed under the assumption that we must operate using largely our own resources. Tom and Keith observed that efforts by major US aerospace contractors might bring about some relief in the long term.

Barry moved on to the AMSAT educational outreach efforts, with particular emphasis on the rationale and methods of implementing this. In the existing environment, funding and launch opportunities heavily favor educational institutions. Our association with them gains us credibility. For instance, NASA interest in and support of the ARISSat-1 project was heightened by the experiment provided by Kursk State University. This credibility will in turn lead to access to low cost launch opportunities. Additionally, educational projects tend to be of interest to the general public, not just the more technically oriented. Finally, we gain program experience. The transition from SuitSat-2 to ARISSat-1 has exposed us to a somewhat different, more stringent set of requirements. This experience will better place us for future cooperation. As part of the tools needed for this new

direction, Barry reviewed the Memorandum of Understanding with the University of Florida.

He also reviewed expected launch opportunities. While unique opportunities may arise, the only foreseeable affordable ones are CubeSats, usually associated with university projects. He announced that former Board member Bill Ress, N6GHZ, will assume the new position of AMSAT Director of Launch Opportunities. Bill will work to develop additional contacts, and the AMSAT ability to locate and utilize opportunities. Barry concluded with a discussion of how to bring in new, younger members. Currently many of the key construction tasks have been assumed by Board members. The workload needs to be reduced to allow more attention for longer term issues.

Secretary's report by Alan Biddle, WA4SCA

In addition to the annual meeting last October, the Board of Directors has held two other formal meetings, by telecon. The first was the November 3, 2009 meeting in which the creation of a Student Membership Rate was approved. The second was the January 5, 2010 meeting in which the Acceptable Use Policy for the AMSAT electronic bulletin boards was approved. Alan requested a formal approval of the minutes of the January 5 meeting. This was moved by Barry, seconded by Tom, and approved unanimously. The approved minutes will appear in an upcoming issue of *The AMSAT Journal*.

Alan also discussed the recent Board of Directors election. This year 813 ballots were received. While not as high a percentage of the membership as desired, it was 13% more than last year. The factors which bear on participation are the ease of nominations, interest in the election, and ease of voting. Both the nomination and voting process are tightly constrained by the AMSAT bylaws. The biggest variable is member interest. While AMSAT is a consensual organization with little controversy, we can be more proactive in encouraging members to become interested in serving and voting by raising the visibility of the elections.

Finally, the Board has moved from the traditional telephone conferences to



multimedia conferencing software. This has greatly improved the ease of information exchange, with considerable room for growth and the potential to decrease travel expenses. However, it does require greater coordination to sponsor a meeting which is still being addressed, especially with respect to specialized groups.

Treasurer's Report by Keith Baker, KB1SF/VA3KSF

Keith addressed the reasons for continuing with a professionally done, "full up" yearly audit, even though doing so incurs a significant organizational expense. Continuing with a full audit is required if the organization is to be successful in soliciting donations from our members as well as major donors (such as the Combined Federal Campaign) who expect credible organizations to conduct such annual professional audits. Costs associated with the ARISSat program, legal matters such as ITAR, and the general economy have produced a highly challenging fund-raising environment. This year AMSAT will incur an estimated net operating loss of \$31,000 and there is significant uncertainty regarding income and expense projections for next year. Several ways to reduce operating expenses were also discussed.

Martha distributed the audit report from Berlin, Ramos & Co. It was moved by Tom that it be accepted, seconded by Alan, and unanimously approved. Finally, it was moved by Tom, seconded by Gould, and unanimously approved that Berlin, Ramos, & Co be retained for the coming year.

Rich Godwin, representing SpaceX, gave a brief presentation on the DragonLab. This is a project to utilize previously flown modules for relatively low cost research projects. It will provide a platform which provides support for the projects, and costs are expected to be based largely on power required rather than mass. At present, they are expecting it to be used in rather low, short duration orbits. Interest was expressed by both parties in keeping in touch for future opportunities.

The issue of ITAR was raised again concerning the IHU3, with respect to the rather arcane requirements for information to have been publically published to allow discussions with our foreign colleagues. The law establishing ITAR requirements is largely framed in terms of traditional methods of publications. This precludes solely using electronic means such as the

Internet. Tom explained that research and other technical institutions publish notes on technical matters in hard copy and make them readily available. Phil Karn, KA9Q, relatively recently won a significant legal decision based on this precedent. Some of these are being converted to print on demand, with a copy sent to the Library of Congress. Accordingly, Tom moved that "The Board of Directors authorizes AMSAT to create new publication called "Annals of AMSAT" for irregular publication of technical documentation." It was seconded by Gould, and approved unanimously. Barry expressed the belief that this would fully satisfy the current legal requirements, but would verify this with our legal sources.

ARISSat-1 Report by Gould Smith, WA4SXM, and Lou McFadin, W5DID

The flight and backup payloads are completed, and will be shipped as Amateur Radio experiment hardware, rather than as a satellite. NASA will be handling the shipping, thus greatly simplifying the process. Lou will be going to Russia to facilitate the integration process, and to resolve any last minute issues. The backup flight article if not needed is expected to be returned to the US in July, 2011. The ground station software is operational, but not fully functional or integrated. However, we need to begin a public relations program to familiarize both the amateur community and the general public with the ARISSat-1 capabilities, equipment needed, and how to use the data received. This is a possibility of providing some practice transmissions through existing satellites.

Manager's report by Martha Saragovitz

AMSAT office operations continue normally. With continuing local volunteer support, work continues to fully integrate the existing records. While not an immediate issue, the building in which the AMSAT office is located has many vacancies. The owners are making efforts to improve occupancy, but this may become a safety or availability factor in the future.

Adjourned for lunch 1205-1225.

Satellite Operations Report by Drew Glasbrenner, KO4MA

AO-7 continues to function well. Its large footprint continues to make it popular despite its hardware limitations.

AO-16 is periodically tested, including the S-band transmitter, but will be too cold to

operate without constantly being reset by a control operator for several years.

IO-26 is in good condition, and the command stations have been able to access basic functions. However, not all of the command codes are known. Efforts will continue to make it functional for communications.

AO-51 continues to function well from a communications standpoint. However, the slow deterioration of the batteries is beginning to impose power budget limitations, and the resulting operational constraints. The upcoming periods of eclipse will make careful operation and monitoring even more critical. Having four command stations, one significantly geographically separated from the others, is helping to compensate for this. Finally, it was decided to exercise a capability to reverse the magnets providing orientation control in late 2009. Over a period of 6 weeks, they were reversed, and then restored to their normal consideration. This had significant effects on both the spacecraft spin direction and rate, and coverage in the Southern Hemisphere. (For more detailed information, see "AO-51 Battery Capacity and Spin Trends," by Mark Hammond, N8MH, and Colin Hurst, VK5HI, in the 2010 Conference Proceedings.)

User Services Report by Gould Smith, WA4SXM

Gould began by discussing membership trends. There continues to be a slow drop in membership. One point raised by Drew during the report is that AMSAT makes most of its services freely available, primarily on the Internet. The result is that many satellite users feel little need to join. There needs to be some emphasis that dues make these services possible. The *Journal* continues to suffer from a shortage of articles which sometimes delays its publication. Another rising complaint is the variability in arrival times. These are beyond the control of AMSAT, and are determined by the US Postal Service for bulk shipments. Field operations are being reviewed as time permits. Inactive members have been removed from the list, and some modest formal requirements are being developed. An effort is being made to expand the audio-visual resources available. The number of hamfests continues to fall, and unfortunately some of those which still exist do not have AMSAT representation. An important goal is to reverse this trend by improving coverage, and revenue, at larger hamfests, and increasing the activity of area coordinators. The AMSAT store is



functioning well, but is suffering from a lack of significant new software and hardware offerings. It was suggested that we consider carrying antennas or other products which are traditionally only available at Dayton. AMSAT continues to need volunteers. In the past year, the advertisements in the Journal have brought in 19 respondents. Tony suggested that in addition to general pleas we consider specifically targeted announcements.

Dayton continues to function well, with the usual 6 booth positions and activities at the AMSAT booth. DARA continues to provide excellent support, both in facilities, and providing a \$5000 matching fund this year. Income is roughly constant, though membership renewals are down slightly. The AMSAT store is taking some of the sales which in the past were made at Dayton. The basic Dayton booth layout is functional, but is largely unchanged in the past 20 years. We need to review whether it is becoming dated, and whether 6 positions are needed every year. Finally, our proximity to the extensive ARRL exhibit significantly boosts traffic. We need to discuss a joint talk with the ARRL on educational and other areas of common interest, as well as talks for the AMSAT forum.

ARISS Reports

Dave Taylor, W8AAS, who is now a representative on the ARISS Council, gave a brief informal report. Contacts, both coordinated and opportune, are at a high rate and are on track to beat McArthur's record. As always, activity levels depend on workloads. The NASA scheduling for ISS operations has been moved from the Johnson Space Center to the Marshall Space Flight Center. This more closely integrates amateur with other ISS operations, thus raising its priority. However, this will also somewhat decrease flexibility. The JSC Office of Education continues to be highly supportive. Finally, Barry Baines is continuing to fill in as AMSAT Vice-President for Human Spaceflight until a permanent replacement has been found.

Lou, W5DID, ARISS U.S. Hardware Manager, discussed the current status of ISS equipment. It continues to provide a wide range of communications opportunities, primarily voice contacts, but also digital and SSTV. A few issues and upgrades are being addressed as time and resources permit:

PTT problem on second D700. May be connector problem.

Need new D700 parameter load. Developed, but not loaded.

Highest priority is battery eliminator for VCH1.

Set up Ericsson in Columbus module. Power cable ready to launch.

Emergency power capability. Power connector of Makita flashlight.

Implement HF capability in the ISS Service module. Have antenna, but on hold due to ARISSat.

Need ISS-Ham 12V power distribution system.

Need 28V for service module.

Programming dongle for D700 to eliminate need for computer access.

Columbus module V/U antennas. Installed and working well.

Want DATV for coverage on downlink.

Next Generation ISS-Ham system. Multiple uplinks, downlinks, and simple interface.

Board of Directors Nominations by Alan Biddle, WA4SCA

Alan reviewed the rules and past history of the nomination process. It dates from the early days of AMSAT when electronic communications were limited to the few at government or other technical facilities. Traditionally we have required written nominations, usually gathered at hamfests, to be received by June 15th. Martha emphasized that we have been very flexible with nominations as to format. However, this is becoming less convenient with electronic communications becoming the normal means of conducting businesses. The AMSAT Bylaws do give the Corporate Secretary considerable leeway in defining acceptable forms for the nominating petitions. In view of this, there is the sense of the Board that we will accept in addition to traditional formats nominations by FAX, PDF, or similar means received by June 15th. This will allow nominations up to the last day should there be an unexpected change in someone deciding to run, or to cover a last minute withdrawal. However, a traditional paper verifying, consisting of names, calls, and individual signatures, will need to be received at the AMSAT office within 7 days following the close of nominations. Electronic submissions without this written verification are not valid under the existing bylaws. The expanded procedure will be used for the 2011 AMSAT Board nominations.

Any more extensive changes, for instance to a fully electronic method, will require an amendment of the bylaws.

New Business

The meeting then transitioned to new business with Gould's discussion of issues involving User Services. Many AMSAT Internet functions are still running on an outside server. Access is very limited, and requires scheduling and paying the operator for major changes. While this has worked for some time, there are significant benefits in terms of cost and ease of maintenance by moving to a commercial hosting site, using a standard system such as Joomla. The sense of the Board was for Gould to negotiate a commercial hosting agreement and to report to the Board when possible. At the last Board meeting there was an extended discussion of merging the many and varied databases used by AMSAT. No suitable migration path has so far been found, and one reason has been the lack of a precise, detailed statement of goals. Accordingly, a team will be formed to review the existing databases and it's requirements, both with respect to existing and future requirements. One particular item which has long been desired is a Members Only section. The intent is to provide some specific value to members without removing information which non-members have long depended on for operations. Some suggestions were made for content, but this needs to be fully reviewed and clarified. Gould moved on to the continuing issue of AMSAT hardware resources. The bulk is in storage in Maryland, and the equipment is in varying levels of repair and usefulness. Others, mostly from the ARISSat project, are in temporary storage in Orlando. Bob Davis will take the lead in handling the Maryland items, with Tony and Lou evaluating which should be kept. Finally, Gould discussed the AMSAT organization and responsibilities of officers. He is looking for statements of responsibilities of various officers, and suggested using the Google Docs system for volunteers. This should allow people to find needed resources more easily.

Engineering Process Report by Tony Monteiro, AA2TX

Tony used the ARISSat-1 project to illustrate the existing strengths and weaknesses in the current way of doing things. Because AMSAT is a volunteer program it has challenges in obtaining material and personnel in a timely and consistent manner. Long lead times are acceptable; slippages are not. Tony



gave a brief tutorial of a recommended method for AMSAT to follow in the future. Keith commented that this also applies to our educational outreach since students are also very different from traditional contractors. The process will need to be iterative, reflecting lessons learned with each process. At Tom pointed out, this is largely new to AMSAT; the Microsat projects were accomplished without formal steps. A consequence of that, brought up by Lou, is that we have no documentation from that period. Finally, Barry observed that the previous generations of builders have retired except as consultants. The new builders are relearning old lessons and developing new techniques.

Tony finished with a discussion of the Fox project, beginning with AO-51 and its functions which will need to be replaced. He progressed through the current state of launch technologies and costs, and how it leads to the current incarnation of Fox as a LEO CubeSat. Finally, he showed how this fits in with educational outreach and the direct application of our ongoing collaboration with SUNY to Fox. (For more detailed information, see: "AMSAT-FOX Preview, Tony Monteiro, AA2TX," "NextGen CubeSat Proposal – Evolutionary Leveraging of Assets and Opportunities, Alex Harvilchuck, N3NP," and "NextGen CubeSat Student Report, the NextGen Satellite Team and Alex Harvilchuck, N3NP," in the 2010 Conference Proceedings.)

The Board entered into a brief closed session at 1750, followed by a working dinner. The Board returned to an open session in order to accommodate scheduling requirements. Alex Harvilchuck, N3NP spoke on the SUNY-Binghamton collaboration. He reviewed the results to date on the power systems, and the use of supercapacitor technology rather than traditional storage cells. He covered the proposed evolution from the ARISSat boards, and the inclusion of attitude and command data systems. Their team will require as much detail as possible from AMSAT to guide development. Finally, he suggested that AMSAT pair with them for NSF proposals. (For more detail, see presentations in the 2010 Conference Proceedings above.)

The Board returned to a closed meeting, adjourning at 2140 CDT.

The Board was reconvened Friday morning at 0805 CDT in closed session by Barry. It was returned to open status at 0910 CDT.

Nick Pugh, K5QXI, addressed the Board briefly on his concern that we were concentrating too much on LEO projects, and that ultimately there was no future there. He felt that we needed to have longer range planning than we have had to date, and need to find ways to achieve MEO and HEO missions. Barry addressed how AMSAT is addressing these issues by appointed someone with good contacts to search for new launch opportunities, but also shifting our interests to reflect the new realities of steadily rising costs.

Barry gave a brief review of the recent history of the search for a new location for the AMSAT laboratory as an introduction of Dr. Norman Fitz-Coy from the University of Florida. Dr. Fitz-Coy presented a summary of the current UF Small Satellite Technology Program. He also reviewed the rationale, costs, etc. for the basic concept of smaller satellites. CubeSats present a smaller "solution space," with projects needing to be carefully matched to this reality. Given that CubeSats are priced by volume, he discussed the suitability for 1 Unit satellites for verification, and 3 Unit satellites for operations. For historical reasons, institutions in Florida have been oriented toward launching satellites. Dr. Fitz-Coy wants to move toward the design and development of spacecraft. Throughout the presentation, there were brief digressions into ITAR issues, which UF is now encountering, and how an association with AMSAT would fit in.

After this presentation, Barry asked about the Board's view of the Memorandum of Understanding which AMSAT and the University of Florida have been negotiating. Keith made the point that the association would benefit us with support in kind rather than cash, with an increase in the accessible opportunities. Tom also briefly discussed how the lack of exclusivity in the agreement would be of benefit to both parties. Finally, after reviewing the relevant AMSAT members in the area, it was decided there is sufficient local representation. It was moved that the MOU be approved by Drew, seconded by Tom, and unanimously approved.

The following people were cited for their particular contributions to AMSAT and its mission over the past year by various members of the Board and other officers:

The entire ARISSat-1 team, led by Gould Smith, WA4SXM and Lou McFadin, W5DID.

Bill Hook, W3QBC, and Bob Carpenter, W3OTC. - Their indispensable office support.

Kermit Karlson, W9XA, and JoAnne Maenpaa, K9JKM. - Organizing the symposium.

The entire *AMSAT Journal* team.

Mark Hammond, N8MH, Kevin Schumann, WA6FWF, Gould Smith, WA4SXM, the OZSAT Team, Mike Rupprecht, DK3WN, Drew Glasbrenner, KO4MA, and the AO-51 Operations Group.

Colin Hurst, VK5HI. - AO-51 flip data and analysis.

Scott Richardson, N1AIA. - For keeping data updated.

Mike Young, WB8CXO. - Continued work on the LVB tracker boxes and Dayton presentation.

Barry Baines, WD4ASW. - Transitional leadership.

Ed Long, WA4SWJ. - For his excellent service as Editor of *The AMSAT Journal*.

Martha Saragovitz. - For her continued excellence in management.

Tony Monteiro, AA2TX. - Becoming Vice-President, Engineering, his ARISSat-1 contributions, and AMSAT Project Management Review.

Jim French, W8ISS. - Satellite Status Report.

Ray Hoad, WA5QGD. - For distribution of Keplerian elements.

Keith Pugh, W5IU. - For doing numerous satellite operations demonstrations.

David M Taylor, W8AAS. - For his representation on the ARISS council.

Bob Davis, KF4KSS. - For his invaluable contributions to several aspects of the ARISSat-1 development process.

Dan Schultz, N8FGV. - For his continued service in preparing the yearly AMSAT Symposium Proceedings.

The final item of business was a review by Martha of the Symposium process this year, and the initial cost estimates. In light of the costs, it is worth considering whether to switch to a biannual meeting.

Drew moved and Tony seconded a motion adjourn. Motion carried unanimously at 1215 CDT. ☸



2011 AMSAT Field Day Competition

Bruce Paige, KK5DO, kk5do@amsat.org

It's that time of year again; summer and Field Day! Each year the American Radio Relay League (ARRL) sponsors Field Day as an emergency preparedness exercise. The event takes place during a 24-hour period on the fourth weekend of June. For 2011 the event takes place during a 27-hour period from 1800 UTC on Saturday June 25, 2011 through 2100 UTC on Sunday June 26, 2011. Those who set up prior to 1800 UTC on June 25 can operate only 24 hours. The Radio Amateur Satellite Corporation (AMSAT) promotes its own version of Field Day for operation via the amateur satellites, held concurrently with the ARRL event.

If you are considering ONLY the FM voice satellites like AMSAT-OSCAR 16, AMRAD-OSCAR-27, SaudiSat-Oscar-50, or AMSAT-OSCAR-51 for your AMSAT Field Day focus. Don't, unless you are simply hoping to make one contact for the ARRL rules bonus points. The congestion on FM LEO satellites was so intense in prior years that we must continue to limit their use to one-QSO-per-FM-satellite. This includes the International Space Station. You will be allowed one QSO if the ISS is operating Voice. You will also be allowed one digital QSO with the ISS or any other digital, non-store-and-forward, packet satellite (if operational).

The format for the message exchange on the ISS or other digital packet satellite is an unproto packet to the other station (3-way exchange required) with all the same information as normally exchanged for ARRL Field Day,

e.g.:

W6NWG de KK5DO 2A STX
KK5DO de W6NWG QSL 5A SDG
W6NWG de KK5DO QSL

If you have worked the satellites on Field Day in recent years, you may have noticed a lot of good contacts can be made on some of the less-populated, low-earth-orbit satellites like Fuji-OSCAR 29 (may or may not be operational), AMSAT-OSCAR 7. During Field Day the transponders come alive like 20 meters on a weekend. The good news is that the transponders on these satellites will support multiple simultaneous contacts. The bad news is that you can't use FM, just low duty-cycle modes like SSB and CW.

THE 2011 AMSAT FIELD DAY RULES

The AMSAT Field Day 2011 event is open to

all Amateur Radio operators. Amateurs are to use the exchange as specified in ARRL rules for Field Day. The AMSAT competition is to encourage the use of all amateur satellites, both analog and digital. Note that no points will be credited for any contacts beyond the ONE allowed via each single-channel FM satellite. Operators are encouraged not to make any extra contacts via these satellites (Ex: AO-27 & SO-50). CW contacts and digital contacts are worth three points as outlined below.

1. Analog Transponders

ARRL rules apply, except:

- Each phone, CW, and digital segment ON EACH SATELLITE TRANSPONDER is considered to be a separate band.
- CW and digital (RTTY, PSK-31, etc.) contacts count THREE points each.
- Stations are limited to one (1) completed QSO on any single channel FM satellite. If AO-51 has the V/U and L/S modes turned on, one contact each is allowed. If the PBBS is on - see Pacsats below, ISS (1 phone and 1 digital), Contacts with the ISS crew will count for one contact if they are active. PCSat (I, II, etc.) (1 digital),
- The use of more than one transmitter at the same time on a single satellite transponder is prohibited.

2. Digital Transponders

For the Pacsats (GO-32, AO-51) or 'Store and Forward' hamsats, each satellite is considered a separate band. Do not post "CQ" messages. Simply upload ONE greeting message to each satellite and download as many greeting messages as possible from each satellite. The subject of the uploaded file should be posted as Field Day Greetings, addressed to ALL. The purpose of this portion of the competition is to demonstrate digital satellite communications to other Field Day participants and observers. Do not reply to the Field Day Greetings addressed to ALL.

The following uploads and downloads count as three-point digital contacts.

- (a) Upload of a satellite Field Day Greetings file (one per satellite).
- (b) Download of Satellite Field Day Greetings files posted by other stations. Downloads

of non-Field Day files or messages not addressed to ALL are not to be counted for the event. Save DIR listings and message files for later "proof of contact".

Please note AMSAT uploaded messages do not count for QSO points under the ARRL rules.

Satellite digipeat QSO's and APRS short-message contacts are worth three points each, but must be complete verified two-way exchanges. **Remember, only one digipeat contact is allowed for the ISS and other satellites in this mode.**

The use of terrestrial gateway stations or Internet gateways (i.e., EchoLink, IRLP, etc.) to uplink/downlink is not allowed.

Sample Satellite Field Day Greetings File:

Greetings from W5MSQ Field Day Satellite station near Katy, Texas, EL-29, with 20 participants, operating class 2A, in the AMSAT-Houston group with the Houston Amateur Television Society and the Houston QRP club. All the best and 73!

Note that the message stated the call, name of the group, operating class, where they were located (the grid square would be helpful) and how many operators were in attendance.

3. Operating Class

Stations operating portable and using emergency power (as per ARRL Field Day rules) are in a separate operating class from those at home connected to commercial power. On the report form simply check off Emergency or Commercial for the Power Source and be sure to specify your ARRL operating class (2A, 1C, etc.).

AND FINALLY...

The Satellite Summary Sheet should be used for submission of the AMSAT Field Day competition and be received by KK5DO (e-mail or postal mail) by 11:59 P.M. CDT, Monday, July 11, 2011. The preferred method for submitting your log is via e-mail to kk5do@amsat.org or kk5do@arrl.net.

You may also use the postal service but give plenty of time for your results to arrive by the submission date. Add photographs or other interesting information that can be used in an article for *The AMSAT Journal*.



You will receive an e-mail back (within one or two days) from me when I receive your e-mail submission. If you do not receive a confirmation message, then I have not received your submission. Try sending it again or send it to my other e-mail address.

If mailing your submission, the address is:

Bruce Paige, KK5DO
Director of Awards and Contests
PO Box 310
Alief, TX 77411-0310.

Certificates will be awarded to the first-place emergency power/portable station at

the AMSAT General Meeting and Space Symposium in October, 2011. Certificates will also be awarded to the second and third place portable/emergency operation in addition to the first-place home station running on emergency power. Stations submitting high, award-winning scores will be requested to send in dupe sheets for analog contacts and message listings for digital downloads.

You may have multiple rig difficulties, antenna failures, computer glitches, generator disasters, tropical storms, and there may even be satellite problems, but the goal is to test your ability to operate in an emergency

situation. Try different gear. Demonstrate satellite operations to hams that don't even know the HAMSATS exist. Test your equipment. Avoid making more than ONE contact via the FM-only voice HAMSATS or the ISS, and enjoy the event! 📡

This form is designed to allow for easy editing in a Word Processor.

AMSAT Satellite Summary Sheet - 2011

Satellite and number of Voice QSO's

AO-27 1 (example)

Satellite and number of CW/RTTY/PSK31 etc QSO's

AO-07 5 (example)

Satellite and Up/Downloads

UO-11 3 (example)

Score Calculation:

Total Voice QSO's	x 1	=
Total CW/RTTY/PSK31 QSO's	x 3	=
Total Up/Downloads	x 3	=
Grand Total		=

Please provide the following information:

Your Field Day Callsign:

Your Group Name:

ARRL Field Day Classification:

ARRL Section:

Power Source (Select 1)

Emergency

Commercial

Your name and home call:

Home address:

Any Comments:





LVB Tracker Box

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Contact Martha at the AMSAT office 301-589-6062 to order.

The complete units will be built in groups, so get your orders in early. Units will be shipped as they become available.

Minimum donations requested for various configurations:

- 1) Bare board - \$20 + S&H - no parts kits available
- 2) Populated board, serial interface - \$100 + S&H - no kit with USB unit, rotor cable and LCD available, we do have a parts list with recommended part numbers and sources.
- 3) Custom Ten-Tec Enclosure powder coat, silk-screened, drilled/punched - \$50 + S&H
- 4) Complete unit - board, USB output, rotor cable, LCD, enclosure - \$200 + S&H **our most popular

Documentation for the LVB Tracker can be found at: <http://www.LVBTracker.com>

Boards and complete units may be ordered from the AMSAT office at 301-589-6062 or from martha@amsat.org

THE R.F. CONNECTION

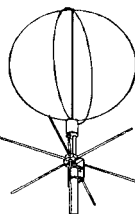
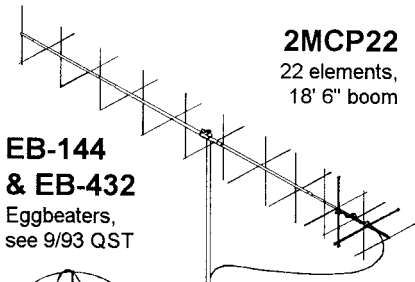
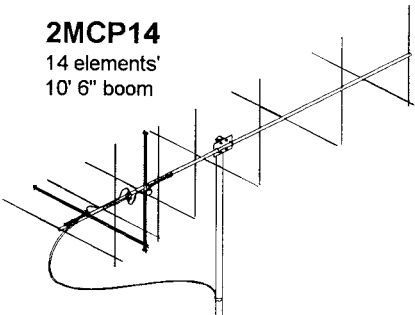
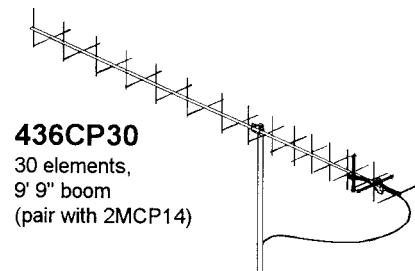
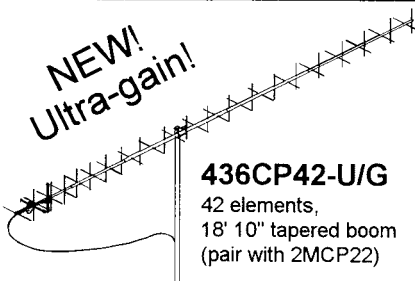
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deliver them directly to the various offices, removing the significant delays found in US Postal Delivery to congressional addresses due to inspection/security concerns with direct mail delivery. Details of this process can be found on both the ARRL and AMSAT Web sites. As you add your own comments, please remember that establishing that you are a constituent, clearly stating the issue of concern, politely stating your position and responding promptly are more important than a lengthy, detailed analysis.

This focus on responding to H.R. 607 is one way that the entire AMSAT membership can make a direct and meaningful impact on behalf of AMSAT's goal of 'keeping Amateur Radio in space'. All it takes is a few minutes of your time and the cost of a postage stamp. Your support of this effort is deeply appreciated.

Finally, I want to thank Allan Biddle, WA4SCA, (AMSAT Secretary and BOD member) for his fine work in leading AMSAT's efforts on this issue. Allan drafted the suggested letter to be sent to Congress that is focused on the concerns of amateur satellite operators, prepared materials to be posted on the AMSAT Web site, coordinated AMSAT's efforts with the ARRL (who has done much over the past two months to encourage Amateur Radio operators to respond to this proposal) and provided follow up as required.

ARRISat-1

Our latest satellite was delivered to the International Space Station on Progress 41P in late January. Energia decided to cancel the planned deployment of the satellite during the EVA that took place on 16 Feb 11 due to their desire to ensure it's availability on 12 Apr 11, the 50th anniversary of Yuri Gagarin's flight.

As I write this in mid-April, it is clear that the special event operation of powering the ARISSat-1 using its internal battery from within the ISS (in a reduced duty cycle mode) attached to an external antenna plus using the Kenwood TM-D7000 that is installed in the ISS to retransmit the satellite's two meter analog signal on the 70 cm band did not work as planned. At this point we don't have any information from RSC-Energia concerning the steps that were taken to prepare for this event and what caused the failure. A special ANS was released on Thursday, 14 Apr 11 by AMSAT confirmed that signals were not received on the ground and outlined the roles and responsibilities of AMSAT, NASA

and RSC-Energia concerning development and deployment of ARISSat-1. A copy of that ANS is included in this issue of the Journal. AMSAT was not involved in the development of plans for special operation from within the ISS and we're anxious to learn from RSC-Energia what their fault analysis has revealed.

AMSAT was previously informed that ARISSat-1 will be deployed during the next Extra-Vehicular Activity, designated EVA-29, currently scheduled for 27 Jul 11. As I write this, we don't know what impact, if any, last week's events will have on the planned deployment. As AMSAT is informed of the details related to deployment, we will work to spread the word to both Amateur Radio and educational-focused organizations and media outlets.

Despite the disappointment of not hearing ARISSat-1 from the ISS during this commemoration, this does not diminish the historical significance of recognizing the 50th anniversary of man's first steps into space. Congratulations to RSC-Energia on a special anniversary and best wishes to all who push the envelope in maintaining a human presence in space.

Dayton Hamvention

May marks the time for the Dayton Hamvention, an annual rite of Spring that many of us look forward to attending. This year's Hamvention will be a busy one for AMSAT. As I write this column, there are a number of highlights:

- Astronaut Doug Wheelock, KF5BOC, who served as Commander of ISS Expedition 27, will be attending Hamvention as a guest of ARRL and AMSAT. He will be spending time at both the AMSAT and ARRL booth areas on Friday and Saturday, attending the ARRL-TAPR dinner on Friday evening, giving a forum presentation on Saturday and interacting with AMSAT people over the course of the Hamvention.
- AMSAT China (CAMSAT) will be at Hamvention this year. Alan Kung, BA1DU, and Michael Chen, BD4RV/4, will be in attendance. As I write this, an AMSAT China delegation is also expected to be at Hamvention. Alan will speak at the AMSAT Forum on Saturday, highlighting HO-68 and how Amateur Radio in space is evolving in China. There will also be two additional CAMSAT representatives (BH4REQ and BA4TA) in attendance at Dayton as well.
- Alex Harvilchuck, N3NP, will make a presentation on the Next Gen CubeSat engineering work being done by students

at SUNY-Binghamton. This development work is the students' senior project and is a continuation of a cooperative effort between AMSAT and IBM/SUNY-Binghamton.

- ARISSat-1 will be highlighted in anticipation of deployment later this summer.
- An overview of Project Fox will be presented by Tony Monteiro, AA2TX, VP-Engineering.
- Our theme this year is "AMSAT: Providing Education Through Amateur Satellites" which summarizes well the focus of our efforts over the past year, including ARISSat-1, the CubeSat development work done with SUNY-Binghamton, and ARISS, which celebrates it's 10th Anniversary this year.

DARA Matching Gift Challenge

The Dayton Amateur Radio Association (DARA) has also announced a fundraising challenge for AMSAT whereby they will match on a 3:1 basis up to \$5,000.00 for donations made in 2011. That is, for every \$3.00 that AMSAT raises, DARA will provide \$1.00 up to a maximum of \$5,000 donated by DARA. AMSAT will be conducting fundraising at Hamvention, where donations will count against this goal. Please consider making a donation to AMSAT at Hamvention or anytime this Spring as we strive to meet this goal. We appreciate DARA's support for AMSAT and see this as an opportunity for donors to increase the impact of their donations by taking advantage of this matching program.

The AMSAT leadership team will be at Hamvention. Please take advantage of this opportunity to interact with both board members and senior officers. If you have issues or concerns that you wish to express, here is your chance to do so.

AMSAT Symposium

It isn't too soon to start thinking about attending the 2011 AMSAT Symposium. This year's event will take place in San Jose, CA the weekend of 4 Nov 11 at the Wyndham Hotel. Herb Sullivan, K6QXB, is the chairman of the event. Given that 2011 is the 50th Anniversary of the deployment of OSCAR-1 and that the satellite was built in California under the auspices of Project OSCAR, we look forward to celebrating this significant milestone for Amateur Radio in space during Symposium. Information on the Symposium will be available at the AMSAT booth at Dayton Hamvention and additional information will be posted on the AMSAT Web site. ☺



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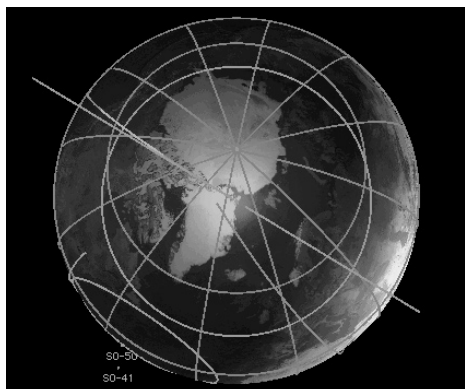
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and any other area you think you think you can make a difference.

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Send your suggestions, actions plans and a description of why you are capable of doing this task to Gould Smith, WA4SXM, wa4sxm@amsat.org



AMSAT at Binghamton University

Tony Monteiro, AA2TX, aa2tx@amsat.org

Introduction

During the 2009 - 2010 academic year, AMSAT sponsored a senior design project at Binghamton University. The project, named the "NextGen CubeSat Project" was done by seven engineering students and fulfilled a key requirement of their graduation curriculum. The intent of the project was to investigate technologies that could be useful to AMSAT on future satellites. The faculty advisor was Dr. Charles R. Westgate, WC2R, who was the dean of the engineering school at Binghamton University and is also an AMSAT member.

The project was originally proposed to the AMSAT Board of Directors by Alex Harvilchuck, N3NP, who in his day job is a systems engineer with IBM in the Binghamton, NY area. The AMSAT board approved the project in the fall of 2009 with Alex as the students' industry advisor and AMSAT program manager. With the school year already started, Alex began in earnest to recruit students to work on it but that turned out to be a particularly easy task as far more students were interested than could be accommodated. The final multidisciplinary team consisted of three mechanical, two electrical and two computer engineering students.

AMSAT members Lou McFadin, W5DID, Bill Ress, N6GHZ, and Tony Monteiro, AA2TX, volunteered to be technical mentors for the students and were joined by Barry Baines, WD4ASW, in their project reviews.

The ARISSat-1 satellite was used as a model to help the students understand some of the issues in working on satellite designs. The students focussed on the power system and the mechanical structure that would be needed to provide an ARISSat like capability in a 3-Unit (3U) CubeSat. A 3U CubeSat is only 4" x 4" x 12" which is much smaller than ARISSat-1 and so this provided an interesting set of challenges.

Binghamton University

The State University of New York (SUNY) is the nation's largest comprehensive system of public higher education and includes 64 colleges and universities. The four university centers consist of Albany, Buffalo, Stony Brook and Binghamton.

The engineering school at Binghamton

University was founded in 1983 and was named for IBM founder Thomas J. Watson. The Watson school offers a comprehensive set of undergraduate and graduate engineering degree programs including mechanical, electrical and computer engineering.

All seniors at the Watson school get a chance to apply their technical knowledge to real-world engineering problems through the senior design project course. These projects are often conducted in cooperation with industry sponsors to help the students get a head start in their engineering careers.

Power System

The main area of investigation for the power system was the use of super capacitor technology to replace the battery. This technology can be used to make capacitors in the multiple Farads range, much higher than conventional capacitors. With enough capacity, they could replace the rechargeable batteries normally used on our satellites. When properly designed, super capacitors can have a very high number of charge/discharge cycles and should last far longer in orbit than NiCd or Li-ion batteries. This is a key benefit as many of our satellites have experienced mission-ending battery failures in orbit. The major downside to super capacitors is that they take up much higher volume and weigh more than rechargeable batteries with similar energy storage capabilities. Nonetheless, this is a very interesting technology that could have applications in future satellites to extend the useful life in orbit.

The students designed and constructed a prototype satellite power system using an array of forty-two, 220 Farad capacitors. Since super capacitors have never been used in orbit, part of the project involved testing them in a vacuum chamber and at extreme temperatures to see if there were any ill effects. The students thermally cycled the capacitors at temperatures as high as 60 C and found no changes in the electrical characteristics. Capacitors were also tested in a vacuum chamber after being sealed with "Torr Seal", a silicon based resin sealant. Again, it was found that the capacitors operated nominally after being exposed to a vacuum for 36 hours. While further research would be necessary before we would be prepared to fly them, the students' work has showed that this is a path worth

considering if the size and weight can be accommodated.

Mechanical Structure

The main area of focus for the mechanical structure involved studying ways to get more area for the solar cells and hence more power. This is a major technical challenge for CubeSats as the small size dramatically limits the available power. The students investigated ways to deploy solar panels in orbit to increase the available solar collection area while still meeting the 3U CubeSat maximum size constraints.

The students designed and constructed a mechanical space frame using standard parts where available and custom fabricated parts as needed. The standard parts, including screws, torsion springs and spring plungers, were purchased from a hardware store. A few custom parts, including the deployable panels, were laser cut at a local machine shop, while other custom parts including the side rails and hinges were milled using a CNC machine. All of the parts were assembled into a prototype space frame and the solar panel deployment mechanism was tested and was successful.

Conclusion

The students documented all of their work in a 100 page report that was submitted as part of their graduation requirements and AMSAT received a copy. With help from Alex, the students also put together a PowerPoint slide summary of their work that was presented at the 2010 Dayton Hamvention by their faculty advisor, Dr. Westgate. Unfortunately, graduation at Binghamton University is held the same weekend as Dayton Hamvention so none of the students could attend, but I am happy to report that they did all successfully graduate. For the benefit of AMSAT members, Alex presented the PowerPoint slides at the 2010 AMSAT Space Symposium in October of last year and demonstrated the structure prototype. After the project was completed, the students wrote brief letters to the AMSAT Board of Directors describing their experiences. Copies of the letters are reproduced on the following page and speak for themselves. ☺

Student letters are on the next page ...



5/7/10

Dear AMSAT Board of Directors,

Thank you for giving me such a great opportunity to work on the NextGen CubeSat project. It was a great learning experience working on a real world project and going through all the steps of the design to fabrication of our prototype. I learned a great deal about super capacitors and pseudo capacitors and what these new technologies hold for the future. I also learned a lot about solar panels and solar powered systems along with satellites and specifically a lot about ARISSat-1 and the CubeSat form factor. I never really realized how long and how much effort goes into formulating a design, building a prototype and especially the amount of testing done to it until now. This experience will definitely give me a leg up as I transition into the work world very soon. Again, thank you so much and I hope that this project is continued next year and for years to come and that we will see this satellite fly in the future.

Sincerely,

Michael Schneberg
Binghamton University Computer Engineering Major

Dear AMSAT Board,

I appreciate the opportunity that was given to me to work on this CubeSat project, which allow for us to design the first Supercapacitor based power system to be used in space. This project had taught me much about Supercapacitors in how they work and what they can be used for. I believe that Supercapacitors will one day replace the battery and this has been a great experience working with them. Thanks again for giving this opportunity to me and I hope the projects will continue for the next year students.

-Sidney Li

Dear Mr. Baines and the AMSAT Board of Directors,

I would like to thank you for the wonderful opportunity you presented me this year. Your sponsorship of the NextGen CubeSat project at Binghamton University enabled me to participate in one of the most rewarding experiences of my life. I was lucky enough to work in an interdisciplinary team of Electrical, Mechanical, and Computer engineers on one of the most interesting and innovative projects Binghamton has ever participated in. During this project I got the opportunity to work with cutting edge technologies such as super capacitors which helped strengthen my engineering skills immensely. This project also allowed me to obtain valuable experience working with a team of engineers. I can't thank you enough for making this opportunity possible.

Thanks again,
Robert Stark

Dear AMSAT,

I would like to thank you for giving me and my senior project team the opportunity to gain valuable engineering experience via the CubeSat project. Designing the mechanical frame and panel deployment for the 3U CubeSat was something that I think was very relevant to my pursuit of a thorough knowledge of engineering concepts, and I came out of this project a much more competent engineer. I sincerely hope that the project is continued in the future by successive project teams. I know that although we accomplished a lot this semester, there is still a great deal to be done. I cannot speak for my entire team, but I am confident that if any questions should arise, my team and I will be available to offer our assistance to AMSAT and future senior project teams.

Once again, thank you for giving me this opportunity. I hope the best for AMSAT and its mission.

Andrew Mills

May 19, 2010

AMSAT Board and Members
850 Sligo Ave. Suite 600
Silver Spring, MD 20910

Dear Lou, Tony, Bill, Gould, Barry, and the rest of the AMSAT members who contributed to and allowed for the sponsorship of the NextGen Cubesat Project at Binghamton University,

Thank you all so much for the chance to be a part of this project. The money donated to sponsor this project is greatly appreciated. However, not only the sponsorship, but the time that some of you spent in the evening teleconferences was also greatly valued. I know that you are all very busy, so thank you for finding some extra time those nights. I certainly hope that this project did not cause any of you to lose as much sleep as we all did.

The opportunity to work on this project has taught me a whole lot more about engineering than a couple semesters spent in a classroom ever could. Not only were there academic and technical lessons learned from this project, but it also provided a glimpse of the other issues that I will soon be encountering in the real world. One of the most important lessons I learned was, that no matter how easy or simple something sounds, it never goes quite as smoothly, quickly, or as effortlessly as you think it should. In addition to this, I also learned that sometimes there is no one to answer the question at hand or help to be found nearby. And because of this, it is necessary to read, research, and take the time to figure things out on your own, sometimes even to find that there is no one real right answer. Finally, the other non-technical thing that I discovered about myself is that I hope to stay far away from any type of work that involves managing others. I sincerely hope that I will be able to stick to doing the fun, hands-on, stuff. However, that's quite enough about me, what I am really trying to get across is that I am grateful for the unique learning opportunity that this project provided.

So thank you all again, and I really hope that this project is able to be continued and refined over the next couple years. I cannot tell you how much of a difference that it makes to be able to work on a real-world type project versus one that the professors have contrived to keep students busy for two semesters. In retrospect, the only thing that I wish that I could have done differently is to have put more quality time into the project to get more done.

Sincerely,
Ian Moore

Ian Moore

May 9, 2010

AMSAT Board and Members
850 Sligo Ave. Suite 600
Silver Spring, MD 20910

Dear AMSAT Board of Directors,

I am writing this to thank you for your sponsorship of the NextGen CubeSat Power and Structure System Senior Design Project at Binghamton University. I believe that the knowledge that I am leaving this project with is invaluable. This project has been an extraordinary introduction to an example of a problem that I might face as I begin my career as an Electrical Engineer.

Having the opportunity to work on this project has taught me a lot about what I should be expecting as I begin my life in the workforce. As the team leader for this project, I have realized that leadership is definitely the route that I would like to pursue in my career's future. Having knowledge of the entire project at hand and having managerial tasks to perform as well as design work taught me how important and valuable time management skills are.

Once again, thank you for this great opportunity. I hope that this project continues to be successful.

Sincerely,

Jason Ketcham



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by Tony Monteiro, AA2TX
- AMSAT-Fox Preview
by Tony Monteiro, AA2TX
- AMSAT NextGen CubeSat Proposal - Evolutionary Leveraging of Assets and Opportunities
by NextGen Satellite Team - Alex Harvilchuck, N3NP
- Ham TV Experiment On-board ISS
by F Azzarello, IW8QKU, E. D'Andria, IOELE, T. Giagnacovo, IZ0LTG, and P. Tognolatti IOKPT
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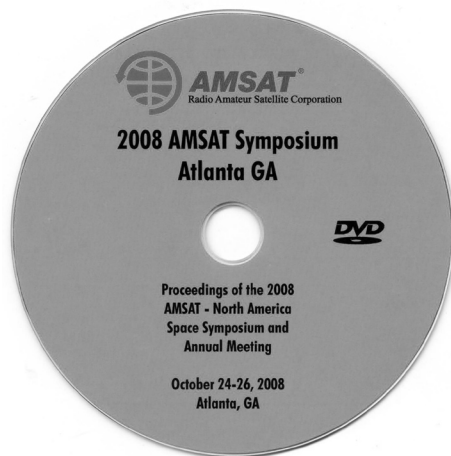
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ARISSat-1 Not Heard During Gagarin Commemoration

[Editor's Note: This article was previously published by the AMSAT News Service (ANS)]

The planned operation of ARISSat-1/RadioSkaf-V/KEDR on April 11 and April 12 from inside the International Space Station as part of the commemoration of the 50th anniversary of Yuri Gagarin's flight was not successful. No earth stations reported hearing transmissions on the ARISSat-1 downlink (145.950 MHz for FM analog/145.920 MHz for digital). The planned retransmission of the satellite's FM downlink via the Kenwood TM-D700 transceiver - currently used for ARISS contacts - was also not successful as no reports were received of signals heard on 437.550 MHz. However, a similar ARISSat-1 transmission test conducted in February was successful, with 145.950 MHz signals being successfully received by several ground stations.

At this point it isn't clear to the ARISSat-1 team what went wrong with the most recent test. Unfortunately, little information has been shared by RSC-Energia concerning plans made to configure the satellite and the interface used to connect the satellite to one of the external ARISS antennas. The status of the satellite's Russian-provided silver zinc battery is also unknown.

ARISSat-1 is a cooperative effort of AMSAT, RSC-Energia and NASA. AMSAT designed and built the spacecraft as a prototype of a proposed series of educational satellites which can carry student-built experiments. The ARISSat-1 prototype features a student experiment designed and built by Kursk State Technical University in Russia. A backup was also provided (without solar panels). AMSAT delivered the two units to NASA's Johnson Space Center in Houston, TX in early October. NASA has led the integration of ARISSat-1 into the ISS flight program. NASA coordinated the logistics of transporting the satellite and a backup unit, including export licensing, from Houston to Moscow. The shipment occurred in early December immediately following RSC-Energia confirmation that the appropriate import documentation had been approved. NASA also conducted the three-phase Payload Safety Review that ARISSat-1 had to pass to be permitted to be shipped to the ISS and deployed from the Space Station. Per protocol agreements signed by

AMSAT, NASA and RSC-Energia, RSC-Energia assumed full responsibility for ARISSat-1 after NASA shipped the prime and backup units. RSC-Energia's stipulated responsibilities included integration of the Kursk experiment, providing a silver zinc battery for the spacecraft, shipment of the primary flight unit to the ISS via a Progress Cargo vehicle (which took place in January 2011) and subsequent deployment during a planned Russian EVA in February 2011.

Once AMSAT shipped ARISSat-1 and the backup unit in early October, AMSAT was no longer directly involved with management and operation of the satellite. AMSAT agreed to send a representative to Moscow (Lou McFadin, W5DID) to assist with testing and final checkout of the satellite once it arrived from the US. Lou was accompanied by NASA's Mark Steiner, K3MS, and the requests for visas and access to the RSC-Energia facilities was coordinated by NASA. Due to visa limitations (Russia does not allow changes to visas once individuals are in Russia), the window for Lou's and Mark's time in Moscow could not be changed once it became apparent that the shipment was being held by Russian customs and wouldn't be released until after the expiration of visas. During the time that Lou and Mark were in Moscow, testing procedures were drafted and agreed to by RSC-Energia's principal investigator for ARISSat-1 (Sergey Samburov, RV3DR) as a signed protocol to assist the Russian engineers with testing and checkout without the presence of AMSAT. Lou and Mark departed Moscow on 22 Dec 10 for the US and the satellite with the backup unit were subsequently released from Russian customs and delivered to RSC-Energia on 28 Dec 10 following submission of appropriate documentation by RSC-Energia.

In addition to the missed opportunity for AMSAT and NASA to participate in the checkout in Moscow, the delayed release from Russian Customs also meant that the satellite arrived in RSC-Energia just as they were commencing a 10-day total holiday shutdown from 1-10 Jan 11. To make launch of the Progress 41P cargo vehicle to the ISS in January, the satellite had to be flown to the Baikonour Cosmodrome on 11 Jan 11, the day after RSC-Energia personnel returned from their holiday. Sergey Samburov, RV3DR, spent a period of time during the

holiday period conducting a checkout of the satellite, but it is still unclear whether the documentation provided by Lou McFadin and Mark Steiner and agreed to as a protocol was followed. For example, AMSAT and NASA have yet to receive any of the full set of closeout photographs of the satellite's exterior stipulated in the protocol.

The satellite did make the flight to Baikonour and was subsequently flown to the ISS on 28 Jan 11 on Progress cargo vehicle 41P. Once the satellite arrived at the Space Station, there was another unexpected alteration to the original plan which has been previously agreed to by AMSAT, NASA and RSC-Energia. Russian officials now wanted confirmation that the satellite was in working order prior to EVA deployment. Why this decision was made was never fully explained to AMSAT or NASA. Even though the satellite was never intended to be operated from inside the ISS, the RSC-Energia team made plans to operate ARISSat-1 from inside the ISS during the period 10-13 Feb 11, connecting the two-meter transmitter to one of the external antennas used for ARISS contacts with the intent of getting confirmation from ground stations that the satellite's transmissions could be received by Amateur Radio stations on the ground. This unexpected development raised AMSAT and NASA concerns given the potential for damage to the spacecraft inside the ISS and the possibility of misinterpretation of results. Despite these concerns, the test was successfully conducted on 10 Feb 11 for 20 hours with the Kenwood TM-D700 on the ISS used to verify normal transmission from the satellite. Ground stations, including Tony Monteiro, AA2TX, did provide reception reports confirming successful operation of the satellite.

ARISSat-1 was scheduled to be deployed during Russian EVA-28, scheduled for 16 Feb 11, as one of the planned tasks on that EVA. However, AMSAT and NASA were informed on 11 Feb that RSC-Energia officials decided to remove the satellite deployment from the Russian EVA-28 schedule of activities due to complications with another task scheduled for that EVA. AMSAT and NASA were informed that the ARISSat-1 deployment would be rescheduled and included as a task in the

continued next page ...



next Russian EVA, currently scheduled for July 2011. Around the same time, the RSC-Energia Principle Investigator mentioned the possibility of a “special event involving ARISSat-1” around the date of the 50th anniversary of the Gagarin flight commemoration on 12 Apr 11. AMSAT and NASA inferred that, by retaining the satellite onboard the ISS until the next Russian EVA in July, RSC-Energia could ensure that the satellite could be activated within the ISS specifically for the Gagarin Commemoration.

During the period from the testing on 10 Feb 11 to the planned time of activation on 11 Apr 11, the satellite was placed in storage on the ISS. AMSAT and NASA were not informed of the configuration the satellite was in when it was stored, though it appears that the Lexan covers over the solar panels had been removed and replaced by ‘soft covers’ that were meant to be used only in preparation for deployment. We were not informed if the satellite was deactivated following the test, or if the battery was disconnected to prevent drainage, or if the satellite may have been inadvertently left on. Given that operation of the satellite from within the ISS was never part of the original plan and these activities took place without AMSAT and NASA involvement, the ARISSat-1 engineering team is in the dark concerning the impact of storage on the satellite. As the originally agreed-to plan was to deploy the satellite within only a few weeks of arrival on the ISS, there were no provisions made in the satellite design to prepare the satellite for long-term storage on the ISS.

Adding to the lack of information was that the primary RSC-Energia Principle Investigator for ARISSat-1 went on vacation for the entire month of March and there wasn’t a designated backup to coordinate with AMSAT and NASA. Sergey, RV3DR, returned from vacation on 1 Apr 11, but was unavailable for the regularly scheduled weekly conference call that was scheduled to take place on 5 Apr 11. This meant that AMSAT and NASA were not apprised of the details for planned operation of ARISSat-1 for the Gagarin Commemoration until late in the first week in April. AMSAT sent out a press release to the media on Friday, 8 Apr 11, as well as a special ANS Bulletin containing the information that had been provided to AMSAT through information gathered by our counterparts at NASA who have access to a schedule of the planned

daily activities of the ISS crew.

The documentation for the configuration and operation on 11-12 Apr was developed by RSC-Energia without AMSAT or NASA input. AMSAT and NASA were provided a draft plan only a couple of days prior to operation; that document was in Russian and we could not comment on it prior to planned activation. One new development was the last-minute decision by RSC-Energia to retransmit the ARISSat-1 two meter FM downlink on 70 cm by configuring the Kenwood TM-700 that is currently used for ARISS contacts in cross-band repeat mode. The ARISS team was asked for a recommendation on which frequency would be appropriate to use, and the suggestion was made to use 437.550 MHz. However, procedures for configuration of the TM-D700 were not shared with AMSAT or NASA. There remains the distinct possibility that the unsuccessful result of this test was due to a misconfiguration of ARISSat-1, its interface to the ARISS external antenna, or the TM-D700.

An additional consideration is that the Cosmonauts who were available for the Gagarin Commemoration were not necessarily the same individuals involved with the test in early February due to a planned crew rotation that took place in early April, where three individuals (two Russian, one American) were flown to the ISS to supplement three individuals who were still onboard.

Neither AMSAT nor NASA received any status reports directly from RSC-Energia during the timeframe of the planned operation. We also don’t know what the Cosmonauts found when they operated the three activation switches on the control panel, such as whether the LEDs were lit or not. The status of the flight battery is currently unknown to AMSAT and NASA. Hopefully, RSC-Energia will provide an update on the status of the satellite to AMSAT and NASA and a determination can be made of the health of the satellite.

As noted above, ARISSat-1 is made possible through the cooperation of RSC-Energia, NASA and AMSAT. However, the degree of information received from RSC-Energia has been very sporadic, given that ARISSat-1 is technically a Russian satellite (callsign RS01S), and, per the signed protocol agreements, RSC-Energia has assumed full responsibility for all activities associated with ARISSat-1 from pre-launch preparation

in Moscow through EVA deployment from ISS. Indeed, RSC-Energia has never publicly acknowledged that AMSAT was the organization that built the satellite nor the significant NASA involvement in the project. Clearly, what our expectations are concerning ‘transparency’ of information does not coincide to what RSC-Energia has been willing to share to date.

We will continue our efforts to gain insight from RSC-Energia concerning what transpired regarding their planned Gagarin Commemoration event. We’re anxious to know the status of the satellite as well as prospects for deployment in July. We are dependent upon the willingness of RSC-Energia to keep AMSAT and NASA informed. As we are apprised of developments, we will share that information. ☺

AMSAT at the Puyallup Hamfest

Earlier in the year Bob Johnson, W7LRD, and some friends set up an AMSAT booth to introduce local hams to satellite radio. In a note to Martha in the AMSAT office Bob said, “Try to say Puyallup three times real fast! We had a good hamfest. I convinced a few you don’t need a PhD to play with satellites and raised \$160, which I will be sending to you along with the box of goodies.” Here’s a picture of Bob and the gang.



Bob, W7LRD, (left) and friends man the AMSAT booth at the Puyallup hamfest.

Predictions of the Orbital Lifetime of ARISSat-1

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Introduction

ARISSat-1 [1] will be released from the International Space Station, ISS (Zarya) (25544), during an extra-vehicular activity currently expected to occur during a July 2011 spacewalk by Russian cosmonauts. During April 2011 the Sun was increasing in activity producing a higher 10.7 cm flux, which causes the Earth's atmospheric density to increase at LEO altitudes. The actual orbital lifetime will depend on the initial release height and the actual atmospheric densities encountered during the mission. The predicted lifetime of ARISSat-1 ranges from as low as 67 days to as long as 152 days depending on the actual release height and atmospheric density encountered.

ARISSat-1

ARISSat-1 is 6-sided rectangular cuboid with dimensions 0.55m x 0.55m x 0.40m [2]. To predict orbital decay we must first compute the drag area in the forward velocity direction. ARISSat-1 has no attitude control so it will be a random tumbler satellite. An appropriate drag area to use then is to simply generate the average area of the two main faces. Area 1 (A1) is made up of the +z, -z faces and is the larger area. Area 2 (A2) includes the +x, -x, +y, -y faces and is the smaller area. The Kursk State University vacuum experiment cylinder extends above the +z deck but this area is not explicitly added. Estimates were made of the area of the vacuum experiment cylinder from photographs of the area of the vacuum

measurement experiment cylinder is about 2.5% of the total area. This error is relatively small compared to other expected error sources. The decay prediction software uses a cannonball model so the average area was finally reduced to an equivalent diameter which produces the same area. Finally the area/mass ratio and mass/area ratios were produced for comparison to other spacecraft. The area and diameter computation proceeds as shown in Figure 1.

ISS Altitude

The ISS, in recent years, has been maintained between about 330 km and 360 km on average above the geoid. The ISS orbit is generally maintained to be nearly circular. The ISS orbit is raised several times a year to offset air drag induced orbital decay. The orbit raising energy is produced by using the engines of the various resupply vehicles, or the space shuttle engines. We won't know the actual release height of ARISSat-1 until the event occurs, so a range of predictions were produced from heights ranging between 330 km and 370 km at every 10 km step.

Orbital Decay Prediction

The Semianalytic Theory of Motion under Air drag and Gravity (STOAG) is a software tool written by Ales Bezdek and uses a semi-analytic theory to model the motion of satellites under air drag [3]. Inputs are the solar flux, A-index, orbital elements, start date, mass, Cd and the satellite equivalent diameter. STOAG uses the TD88 atmosphere based on the MSIS model, includes the gravity field to the 9th order and lunar and solar perturbations are included. Cd is an error soak term, which may change due to errors in the atmospheric density models and the fact ARISSat-1 is a cuboid not a sphere. So predictions were produced for Cds of 1.9, 2.1 and 2.3 at each height to allow for some variation in parameters.

Solar flux (90 day average) and the daily A index data were obtained from the space weather files located on the Celestrak Web site [4]. The author produced the long-term smooth cycle average flux. See Figures 2 and 3. Solar radiation pressure is not explicitly accounted for in the software. Integrations of the orbit proceed with output at a daily rate. This software has been used by this author for many post and pre-mission decay analysis efforts. A representative example is the paper analyzing post mission decay

of the precursor to ARISSat-1, specifically Suitsat-1 and Suitsat-1 debris [5].

The starting orbital elements used to produce the predictions are typical of an ISS orbit, notably an inclination of 51.6 degrees and a low eccentricity of 0.0011. The semi-major axis was adjusted to produce the release geoid heights desired. The predictions start on 15 July 2011, which is defined as mission day 0. As expected, higher values for Cd and larger drag values are related to shorter lifetime of the orbit.

Table 1 and Figures 4 through 8 show the release height, Cd used and the predicted mission lifetime. A common rule-of-thumb would be to assign a +/- 10% uncertainty to the lifetimes predicted. For example, the 370 km release height and Cd of 1.9 gives a predicted lifetime of 152 days with the 10% uncertainty rule indicating +/- 15.2 days. The actual mission lifetime may be outside of these bounds, of course, depending on how much actual conditions deviate from the parameters used to produce the lifetime predictions.

Conclusion

ARISSAT-1 will decay fairly quickly due to the fact it is being released from the low-altitude orbit of the ISS. From the predictions produced for this paper the lifetime will range between 67 days and 152 days depending heavily on the actual release height, sun state and atmospheric density.

References

- [1] <http://www.arissat1.org/v3/>
- [2] http://www.energia.ru/en/iss/iss26/progress_m-09m/photo_01-24_02.html/
- [3] Bezdek, A. and Vokrouhlick, D., (2004), "Semianalytic Theory of Motion for Close-Earth Spherical Satellites Including Air Drag and Gravitational Perturbations", *Planetary and Space Science*, 52, 1233-1249.
- [4] <http://celestrak.com/SpaceData/>
- [5] DeYoung, J. A., "Introducing the Party of Suitsat-1 and Debris: All Dressed Up and Nowhere to Go but Down", *The AMSAT Journal*, November/December 2006, pages 19-21. ☼

Figures continue on the following pages ...

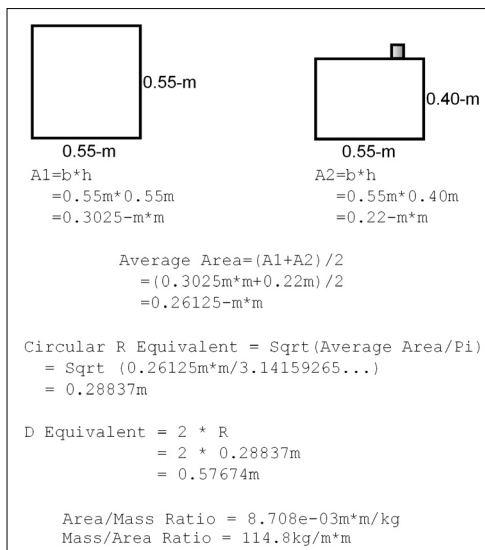


Figure 1: The computation of the drag area, D equivalent and the area/mass ratio are produced.



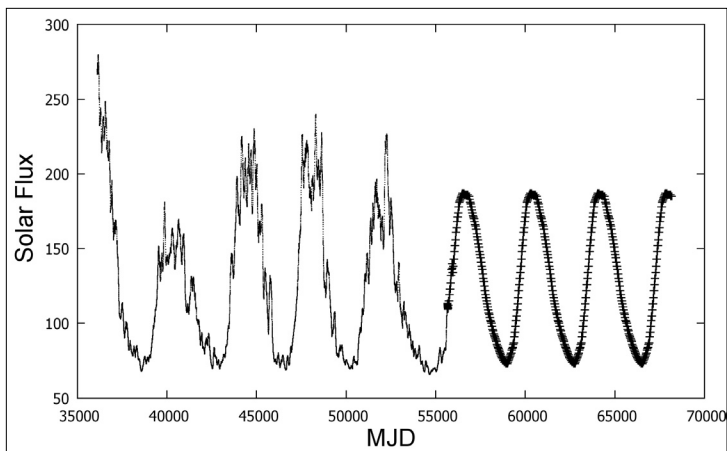


Figure 2: The 10.7 cm solar flux as observed from 1 Oct 57 (dot symbol) to 8 Apr 11 and future predicted solar flux data produced by the author to 2015 (large filled circles).

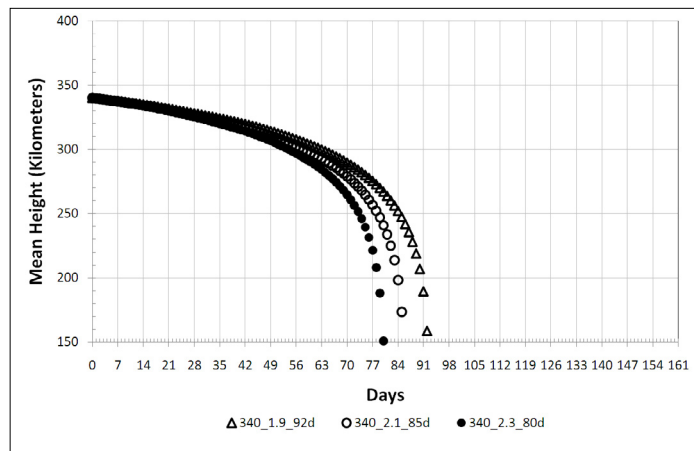


Figure 5: This is the 340 km release height series of ARISSat-1 lifetime plots.

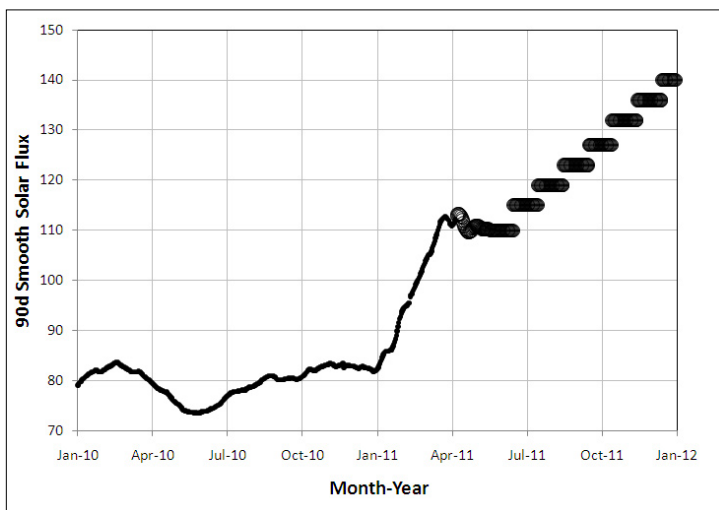


Figure 3: The solar flux observed from 1 Jan 10 to 8 Apr 11 (dots). The first 40 days predicted solar flux data are taken from the Analytical Graphics data file [2]. The long-term predicted data to 1 Jan 12 are from the author's own average solar cycle prediction (O symbols).

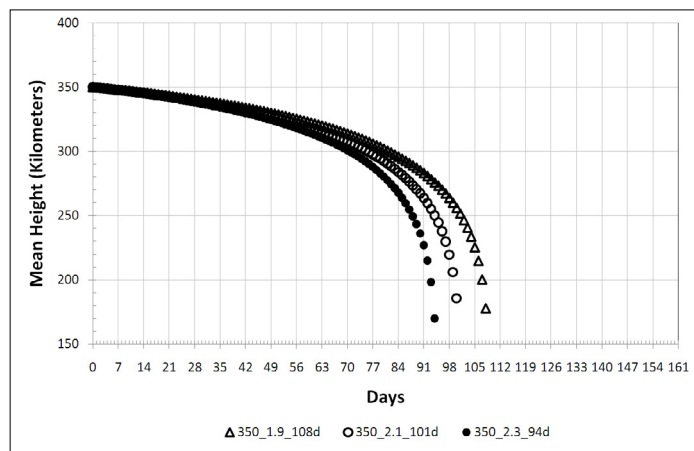


Figure 6: This is the 350 km release height series of lifetime plots.

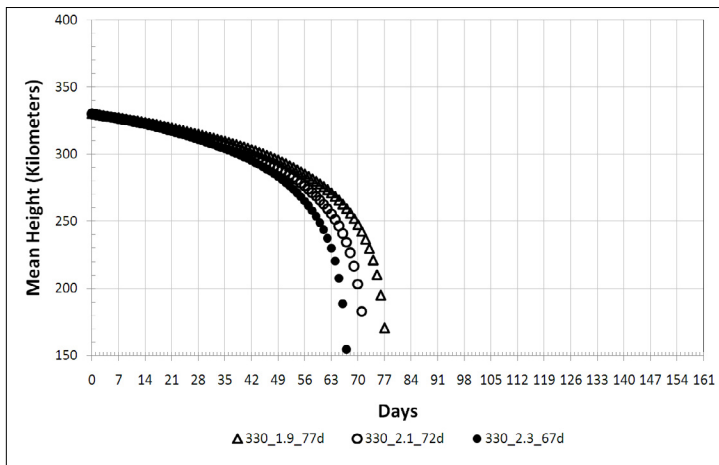


Figure 4: This is a plot of the 330 km release height for Cds of 1.9, 2.1 and 2.3. This is the first of a series of satellite lifetime plots. The x-axis starts at mission day 0, release date. The scale increases with a 7 day (1-week) step. The next five plots are on the same scale to allow for direct comparison between them.

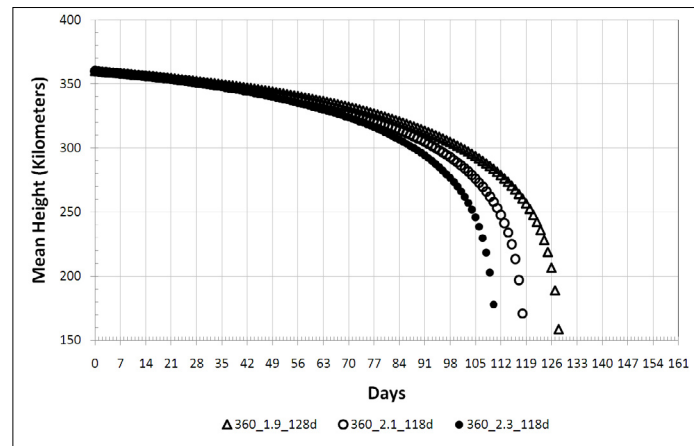


Figure 7: This is the 360 km release height series of satellite lifetime plots.

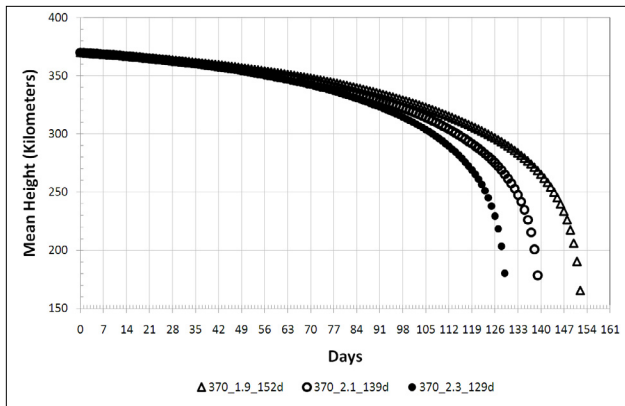


Figure 8: This is the 370 km release height series of ARISSat-1 lifetime plots.

Release Height (km)*	Cd	Lifetime (days)
370	1.9	152
370	2.1	139
370	2.3	129
360	1.9	128
360	2.1	118
360	2.3	110
350	1.9	108
350	2.1	101
350	2.3	94
340	1.9	92
340	2.1	85
340	2.3	80
330	1.9	77
330	2.1	72
330	2.3	67
* above geoid		

Table 1: Shown are the prediction release height, Cd and mission lifetime in days. A higher release height and lower Cd allow for longer mission lifetimes.

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